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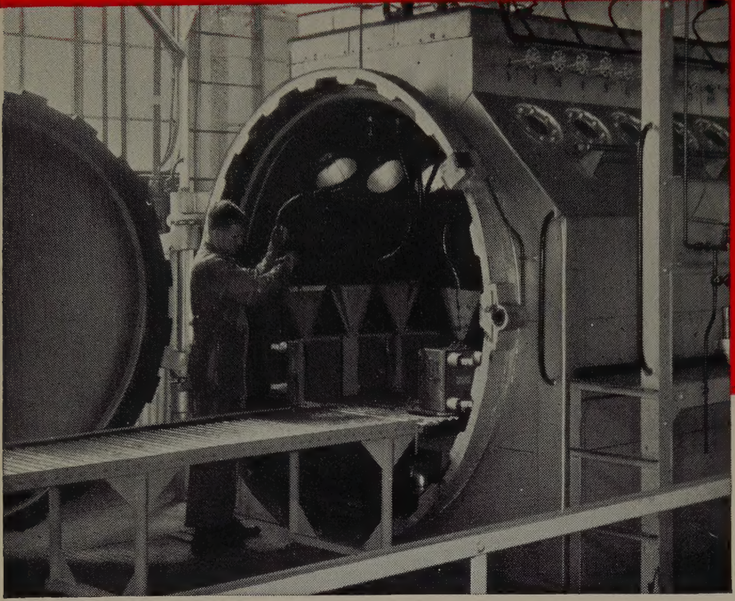

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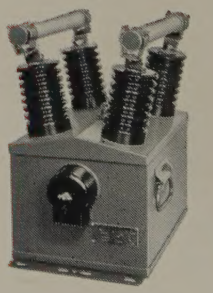

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The Cover: The *S. S. United States* at sea. The new liner is the subject of an article in this issue (pages 230–5).
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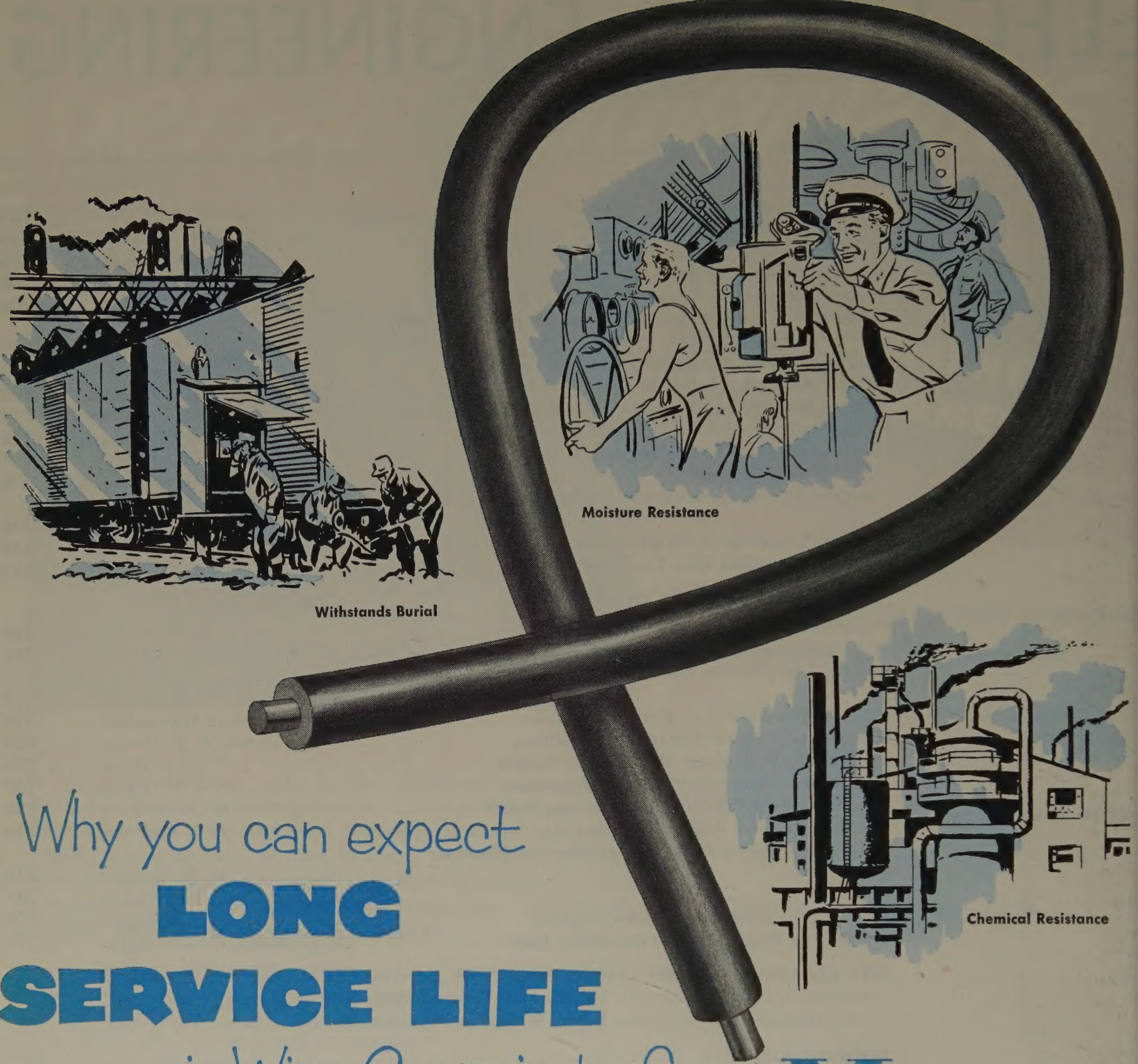

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AIEE Progress

D. A. QUARLES
PRESIDENT AIEE

In his address before the AIEE Winter General Meeting, President Quarles reviews some matters of current interest to the engineering profession, and to members of the Institute in particular.

THERE ARE A number of matters of broad general concern to the Institute which I feel should be discussed at this time. These fall neatly under the title "AIEE Progress," for the very simple reason that progress is the keynote of all the important things that are happening in the Institute today. Our technology is broadening and deepening at a very rapid rate with the natural consequences that our membership continues its rapid growth, and our technical committee structure and technical programs continue their strong upward trend. Institute membership has just passed the 45,000 mark, although it seems that the Board of Directors will have to act on a list of some of our members who have been carrying a little too far the practice of throwing unopened mail into the waste basket, and as a result are at the point of being dropped for dues delinquency. While this may mean a temporary setback in enrollment, it certainly will be a very transient one, and 45,000 soon will be left as far behind as 40,000 was 2 or 3 years ago.

Of particular interest are several important changes in organization. In a sense these center around Secretary Henline, who is looking forward to retiring next year from his many years of leadership and arduous duties at Headquarters. Fortunately, we have been able to make some very fine moves to plug the gap which he will leave. N. S. Hibshman ultimately will succeed Mr. Henline, and his election as Assistant Secretary has required him to resign as Treasurer, Director, and a member of the Executive Committee.

The Treasurer's post which was thus vacated will be filled by W. J. Barrett, who for a number of years has been chairman of the Finance Committee, and thus is a very appropriate choice for the office. While Mr. Barrett resigns as chairman of the Finance Committee, he will continue as a member. C. S. Purnell, now a member of the Finance Committee, will assume the chairmanship and also will fill the Executive Committee vacancy created by Mr. Hibshman's resignation. The vacancy on the Board of Directors is being filled by the appointment of L. F. Hickernell, now chairman of the very important Committee on Technical Operations, which not only makes his advice and counsel available to the Board, but gives the Technical Operations Committee desirable direct representation there.

ORGANIZATION OF THE PROFESSION

RECENT EVENTS make it important that the matter of organization of the engineering profession be touched upon. Those of you who have been able to follow the subject at all closely know that this has recently been a matter of active consideration in Engineers Joint Council (EJC). Under the chairmanship of AIEE Past President H. S. Osborne, an EJC Committee on Increased Unity in the Engineering Profession has given very careful study both to the objectives of a unity organization, and the best ways and means of achieving them. It is perhaps an understatement to say that the constituent societies of EJC have been by no means unanimous in their views of this matter. At the same time it is gratifying that a considerable amount of common ground has been developed. In any event, it became apparent last year that there were certain preliminary moves that would be desirable, and to this end changes in EJC constitution were submitted to AIEE and the four other member societies. These changes provided:

1. That representation on the Joint Council be by election or appointment of each member society rather than on an ex officio basis.
2. That membership in the Joint Council might be expanded by inviting other qualified societies to participate as members, on the approval of two-thirds of the present members.
3. That representation of member organizations would be on the proportional basis of one representative for each 10,000 members or major fraction thereof.

With the approval of these changes by the fourth constituent society on December 7, 1952, the new EJC constitution went into effect. The first meeting under the new constitution was scheduled for January 23, 1953. This will mean among other things that AIEE will be entitled to one or two additional representatives beyond the present three, depending on whether total membership falls just above or just below 45,000 at the time of the count.

In line with the adoption of the new constitution and approval by the constituent societies, seven additional engineering societies have been invited to join EJC as follows: American Association of Engineers, American Society for Engineering Education, American Society of Heating and Ventilating Engineers, Institute of Aeronautical Sciences, Institute of Radio Engineers, National Society of Professional Engineers, Society of Naval Architects and Marine Engineers.

The action of these additional societies has not been announced. It seems safe to assume, however, that in

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Essentially full text of an address presented at the general session, AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

D. A. Quarles is president, Sandia Corporation, Sandia Base, Albuquerque, N. Mex.

the very near future the number of engineering societies represented in EJC will be more than double the present five, and that in other respects the EJC constitution will have been liberalized and strengthened. While this is a step in the right direction, it never has been interpreted to be the achievement of the kind of unity organization the AIEE, at least, believes to be essential. Our representatives on EJC are well aware of this, and will continue to press for further constructive steps in the direction of professional unity. Past President Titus LeClair has been chairman of EJC through this period and both he and Mr. Osborne should be commended for their constructive leadership.

One of the societies that have been invited to join EJC is the Institute of Radio Engineers (IRE). In addition to the broad moves toward unification of the profession as a whole, AIEE and IRE have had their own program of co-operation which has been very effective. The main instrument for such co-operation has been the AIEE-IRE Co-ordination Committee, which passes on all policy matters of joint interest to the two organizations. One very important outcome of this co-operation has been the formation of joint AIEE-IRE Student Branches in many of the universities. This has not only been constructive from the standpoint of electrical engineering students, but tends to orient them toward the closer pulling together of the two Institutes. As stated by the Board of Directors last year, it is AIEE policy to encourage closer relations between the two organizations. Our relations with D. B. Sinclair, who has just retired as IRE president, and with J. W. McRae, who has succeeded him, lend much encouragement to this point of view.

SOME OTHER ITEMS OF INTEREST

Another topic of great current interest is engineering manpower largely because of the present shortage and the dim prospects in the future for an improvement in this respect. As this is a matter of common interest to all of the engineering societies, it was taken up by EJC, which established the Engineering Manpower Commission under the able chairmanship of Carey H. Brown. The primary objectives of this Commission were to study engineering manpower and the factors creating the present shortage; to promote better utilization of engineers both within industry and by the military; and to stimulate engineering education and thus seek to offset the sharp shrinkage in the output of engineering colleges. While more recent statistics have been slightly more favorable than earlier predictions, the estimated output of engineers from the colleges is still far below the national needs. The seriousness of this shortage is importantly influenced by national policy in respect to such matters as Universal Military Training, Selective Service, and misutilization of engineers by the military services and even by industry. This is a good illustration of the community of interest among the engineering societies, and of effective joint action. Relations with both the executive and legislative branches of the government, and with a number of other national organizations interesting themselves in the manpower problem are involved. There is a continuing need for such an EJC Commission. The AIEE is co-operating fully. One important action has been to inform AIEE Sections all over the country of the situation, and to encourage them to work on the local level, particularly in stimulating enrollment in the engineering colleges.

Another matter that repeatedly comes up for discussion is the planning for a new Headquarters building. The present building is held in trust by United Engineering Trustees (UET), and the Real Estate Committee of UET has spearheaded the attack on the building problem. It has been pretty well concluded that the present building is inadequate today and grossly inadequate to the future needs of the engineering profession. Moreover, architects who have studied the situation advise that its renovation and enlargement to do the job would be impracticable. This has lead the UET committee to consider other alternatives, not overlooking the possibility that some benefactor might be found to do for the engineering societies what Andrew Carnegie did over 50 years ago in donating funds for the present building. Actually no such benefactor has been found, and UET thinking is tending to crystallize in the direction of the professional societies joining together to take care of the matter by their own initiative and resources. At the last meeting of UET the Real Estate Committee was instructed to draw up a definite plan for presentation to the Board of Trustees, and in turn to the Founder Societies for their consideration and approval. Several of the societies, including AIEE, have indicated that they have substantial reserve funds which could be made available for such a building project. It is still an open question as to just where such an engineering headquarters building should be located, which leaves it open for any city that considers itself to be an appropriate location for such a center to come up with its best proposition. Undoubtedly this is a problem of substantial magnitude, however it is one that the engineering profession certainly can solve for itself if it resolves to do so.

Before closing I should like to revert to the matter of unity organization of the profession. There is a lot of grass roots interest in AIEE, and surely also among the members of the other engineering societies, in this matter. Certainly it is encumbent on the governing bodies of these societies, including this Institute, to seek out these views and to shape their policy best to meet the interests of the membership. As would be expected, these grass roots views do not always reflect an over-all understanding of the problems involved, but this is an argument for improving the flow of information to the membership rather than an argument for discouraging their interest. There is one particular point on which I would like to comment, and here I am expressing my personal views rather than the policy of the Institute. This has to do with what one might call the economic aspect of the question. One frequently hears, for example, such statements as "definite consideration should be given to the economic as well as the professional status of the engineer." With this I think we could all agree if we were allowed to put our own construction on the words. My own view is that such questions should be tested by the broad principle that the unity organization should serve the common welfare, as distinguished from the welfare of one economic group as against another. To illustrate the point, it would, I believe, be a proper function of such an organization to seek to raise the standards of the engineering profession, and at the same time to enhance public appreciation of the profession on the ground that such actions would tend to encourage more, and more capable, individuals to enter the profession. Certainly the economic health and vigor, not to mention the security, of the nation as a whole would be promoted in this way. The recent work of the Engineering Manpower Commission is another good illustration. Unlike the medieval guilds, who sought to promote the welfare of the guild by monopolistic methods which held down membership, the Engineering Manpower Commission has been addressing itself to the national problem of shortage of engineers, and ways and means of relieving this shortage. This serves the common welfare, and only indirectly the welfare of engineers as a group.

While I do not at all imply that efforts to improve the economic status of the engineer are improper I do hope that we can keep the objectives of the proposed national unity organization on a high professional plane, in the faith that by serving the national welfare as a prime objective, such an organization, in the long run, would best serve the interests of the engineering profession; and conversely, that any tendency to lower its sights and direct its efforts toward more selfish ends, in the long run would injure rather than advance the profession.

The Engineer—His Growth

A. C. MONTEITH
FELLOW AIEE

The growth of an engineer can be evaluated both in terms of his professional growth and of his growth as a member of society. Here one must consider not only the young engineer's responsibility to himself, but the responsibilities of the company which employs him and the goals to which such growth can be expected to lead.

THE SUBJECT of this article, "The Engineer—His Growth," is obviously a complex topic of tremendous scope. It becomes even more important when we recognize, as the public frequently does not, the vital role which the engineer plays in our material life.

With a subject of this breadth, an evaluation of engineering growth would be much easier to organize if it were prepared for a specific experience group. However, what is being discussed here is not how any particular experience group can be expected to grow, but rather how we as engineers can promote the growth of all phases of experience through individual and corporate effort.

If this is our aim, it would seem that pertinent subjects for discussion would include the character of the engineer and what he can do to promote his own growth; what the corporation can do to promote the engineer's growth; and the goals to which this growth can be expected to lead. Probably, the best place at which to start is to discuss the individual and his responsibilities in this great undertaking. What are some of the characteristics a young engineer should have?

He should have his mind fixed on a definite field of endeavor but should allow some flexibility in his thinking.

He should be loyal to the company for which he works.

He must realize early in his career that interest in his job is paramount.

He must be willing to work.

He should be encouraged to be a team player.

He should have determination.

He must expect that his mistakes will be noted.

He must be encouraged to analyze himself continually on all matters but especially to be sure he understands his objectives.

He should be encouraged to accept responsibility.

He should be encouraged to be a businessman.

These points, of course, do not cover all the desirable traits but are sufficient to suggest that in general progress will be made if a reasonable degree of common sense is mixed with initiative.

In this respect, there is one other point that should be made. It has been set aside from the others, not only because it is seemingly paradoxical, but because it is a question which everyone must face at some time in his life. And, while one answer will not necessarily assure growth, the other certainly will limit it.

The question is one of "opportunity" or "security," and in this form it has received a good deal of consideration and a fair amount of discussion in the political field. Generalizations have a way of being misleading, and this is no exception when we imply that there is a choice of either opportunity or security. As a matter of fact, security follows opportunity. For example, consider the automobile

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Essentially full text of an address presented before the Delaware Engineers Association, Wilmington, Del., November 13, 1952.

A. C. Monteith is Vice-President, Engineering, Westinghouse Electric Corporation, Pittsburgh, Pa.

at the turn of the century, and General Motors today, or the chemical industry and the Du Pont organization.

It is essential for the young engineer to choose opportunity if he is to make future growth possible, to choose a job which is challenging and stimulating, one which will give him an opportunity to do real engineering. But, and here is the paradox, the young engineer should beware of impatience. Unfortunately, the engineer with the greatest potential is frequently the most impatient. In all too many cases, impatience has blinded the engineer to the very real opportunities that are all around him.

Russell Conway's story, "Acres of Diamonds," tells of an ambitious young man who set out from his native Persia to look for diamonds. After years of fruitless wanderings all over the face of the earth, he returned home, a bitter and disappointed old man. A little while later, he found his diamond mine—in his own backyard. In other words, opportunity is often within reach simply for the reaching.

THE EMPLOYER'S RESPONSIBILITY

So much for the individual. Now what are some of the responsibilities of others in seeing that he develops at a satisfactory pace?

Considerable attention in recent years has been directed to this problem by the Engineers' Council for Professional Development (ECPD). This group has attempted to develop a program for the individual. Although through committees the ECPD does much work on subjects closely allied to our topic, of most interest in this respect is the Committee on Professional Training which is formulating a program to bridge the first 5 years after graduation. The committee firmly believes that if healthy attitudes are established during this period, from then on the young engineer can put greater effort into his own development.

To achieve this healthy development, the committee has recommended a number of actions.

In the first place, they found it essential that engineers be given the opportunity to do engineering. This may seem facetious, but detailed studies show that much of the work now being done by trained engineers in industry today can be done by supporting personnel. The committee points out that this waste of engineering talent in a time of engineering shortage is not the greatest loss a company can expect unless it rectifies this situation. We must consider also that nonengineering assignments handled protestingly by older engineers adversely affect the young engineer because the attitude of the older man is important to his youthful counterpart. Further, nonengineering assignments for the young engineer can directly discourage him, and even worse, can impair his development by failing to offer the continued challenges essential to growth.

The second step, the committee reported, in assuring that a man grows at the maximum rate is a good training program. The transition from directed development in college to self-development in industry is not easy, and such transition becomes more difficult with every passing day. This is true because industry is becoming increasingly technical and complex. While the craftsman of former years grew up with the business, the college graduate of today steps into a strange organization at a relatively high level. He has had no opportunity to understand, through long association, the methods and operations of the concern. Industry therefore has a dual responsibility in orienting him first into the business world itself and secondly in giving the guidance and training so that he can start building on the foundation provided by his formal education.

At the author's company, the Westinghouse Electric Corporation, the company training plan is called the Graduate Student Training Program. Its aims are to acquaint the first-year engineer with the company and the way it operates, and to find the particular niche where he can get started on his professional career. To accomplish this, an Educational Center near Pittsburgh serves as the main orientation base for graduate students, and they are sent from here to the various divisions so that they will become familiar with the many types of engineering jobs to be done. When an engineer finds a job he would like to do, in a division that likes him, he has found his niche.

The company recognizes that there is no direct teaching method that can do the entire job of developing the engineer professionally. It is only through good training, proper guidance, and continuous encouragement that the graduate engineer can increase his professional stature, but the author can personally attest to the effectiveness of this program in making engineers a part of the productive organization quickly.

Another advantage, and an even more important one, is that a good training program develops healthy attitudes.

The training course brings the engineer into contact with the best men available for training work. Such association provides an enduring beneficial influence on his behavior. He unconsciously builds fences against influences that can reduce his professional status and his individuality.

Then too, by proper training, an industry that was new to a young man a short time before employment becomes a dynamic entity, and he feels a part of it. Consider that the young graduate has been carefully selected as potentially a key man. He reports to work determined to build a reputation. These hopes are increased when he finds that his company is devoting the time and effort necessary to acquaint him with its policies, objectives, and procedures. He realizes that meanwhile he is, at best, only semiproductive but the company sees fit to pay him a salary during the training period. Certainly this company must have plans for him, and he must prepare himself for the opportunities that will open to him.

Contrast this with the direct employment case, that is, hiring an engineering graduate for a specific job and putting him into it with no orientation or training period. He is classed a "productive" employee the first day, and many years may pass before he learns, piece by piece, what the over-all company operation is and how it is organized. He learns the hard way about facilities and services available to him. He may make embrassing mistakes. He feels rather lost in a strange world during his first few years and does not realize where his opportunities lie. In short, he is being pushed into that state of mind that all too often limits his professional development.

Recognizing this, many industrial employers have set up programs similar to the Westinghouse Graduate Student Training Program. But, frequently one hears the comment, "fine, except a smaller company cannot assume such responsibility."

This opinion can be strongly disputed. In fact, a smaller company, taking only two or three graduate engineers per year, has a greater opportunity to personalize the orientation and training program. Because the organization is small, closer contact with the men of experience and leadership in the organization is possible. Elaborate classroom setups, essential in the big company, are not necessary in the small one.

The sincere employer considers high-quality training of the young engineer to be an obligation, and his professional growth a challenge. It is certainly one way to help our young engineers "do more, quicker," and, to that extent, have the effect of increasing our numbers, thus offsetting our present shortage.

In addition to a good program of training, another immediate measure employers can adopt to develop the individual is to urge younger men to continue their education. Good learning habits encourage efficient performance. Morale is kept high if the employer encourages and assists the young engineer in supplementing his college training by evening classes or guided self-study. The maturing and broadening effect is obvious.

In the graduate-study program carried on in co-operation with several universities, in the company's major plant centers, hundreds of engineers are currently broadening their horizons through advanced education. More than 300 men have obtained master's or doctor's degrees through this channel and the rate is increasing each year, and there are as many as 600 to 800 registered annually in advanced study. This program has been expanded to include a few subjects on art and literature, and a program is being formulated where a man may take an advanced degree in business administration. Supplementing this educational work, there are many in-company training jobs which are being aggressively developed and improved.

Although the company's financial support varies with the type of program, in most cases where the student's objective is realized, the company pays tuition fees.

It is recognized, of course, that physical location and other factors may not permit all organizations to sponsor such educational programs. However, encouragement and guidance from supervision will start many graduates in groups of their own in self-improvement programs. The ECPD is aimed at expanding this opportunity for engineers in areas where it does not now exist.

Continuing education has another very real advantage for engineering as a whole. Right now the engineering schools are under pressure from one group which wishes to increase the number of engineering courses, because of increasing specialization. Another group advocates more of the so-called academic courses on the grounds that the engineer must handle business as well as engineering problems. Unfortunately both sides are right to a degree. But the compromise offered, a 5-year engineering course, would seem to place an additional drain on already overtaxed educational facilities, a further deterrent to young men who must carefully weigh the cost in time and money of even a 4-year college course.

It has been our experience that only about 20 per cent of the engineering graduates we hire are engaged in such specialized work that additional formal training is an absolute necessity to the immediate furtherance of their careers. By utilizing a continuing educational program, this specialized instruction is given to the group that needs it most and is generally best qualified to receive it. Meanwhile, the majority of our engineers are free to select training that will be generally helpful to them, rather than a concentrated dose of specific courses which they may never use. Those who are capable, and can afford to do so, should continue their formal education.

THE ENGINEER'S PERSONAL GROWTH

THUS FAR, the discussion has been limited to professional growth of the young engineer. Equally, or possibly more important, is personal growth as a responsible and congenial member of the community.

During the first few years with the company, the young engineer is finding his place in the organization, attempting to understand himself, and shaping his professional attitude, setting his sights on a goal. Frequently, he is establishing his family and generally his salary is modest. Closing the gap between his experience on the campus and realities of earning a living is not an easy task. It is further complicated by the fact that the majority of engineers must build up a new social life at the same time, since there just are not enough job opportunities in either home towns or college towns.

One engineer brought this problem to the attention of the company in no uncertain manner. He was a Southerner married to a girl from Georgia, and after about a month at the Educational Center, he rather reluctantly asked to resign. After a little questioning, he admitted that he liked his assignment and wanted to stay with the company, but that his wife was so lonesome that he felt he had better take her back to Georgia. His resignation was accepted with a 1-week grace period. During that week, the people at the Center induced some other wives to visit the girl from Georgia; also, a program of a social nature was initiated for the graduate students. The young engineer remained in his job and the company is indebted to him for revealing a weakness that few of us were sufficiently aware of to do something about.

At about the same time, one of the ministers in the area heard about this story and he started inviting the new boys, regardless of their faith, to Sunday evening coffee and doughnut parties. The response was so good that it was not long before the Ministerial Council for the area requested lists of the new students so they could be invited to participate in the activities of the various churches. Although much is being said about the decline of the church in these days, more than 80 per cent of the engineers in the training course signify a desire to be brought into contact with a church of their choice.

The Graduate Student Club organized and operated by the students provides for social functions and appoints welcoming committees.

Of course, the Training Center represents a specialized case since personnel is made up of young engineers and the situation is a temporary one pending assignment to a division. We have tried to follow up this social need in the divisions in a number of ways. While each division directs its own program, a majority help the new man to find a place to live, and keep him informed of the cultural, religious, and social life of the community.

A number of employee activities, such as choral groups, athletic teams, sportsmen clubs, public speaking groups, lend further help in acclimating the new employee.

The effectiveness of this program, of course, varies with each division, but even the best program is not the whole answer, since contacts are too frequently limited to colleagues. This seems an excellent place for the local engineering councils to take a hand and welcome the newcomer to the community as well as to the profession. These societies do an excellent job in furthering technical knowledge, but their social events are very limited. The compatibility of professional interest of the engineering societies forms a good nucleus for advancing a social program.

The program envisioned by the ECPD embraces orientation and training, continued education, self-education, and integration into the community. This involves the individual, the employer, a local school, if present, and the engineering council or association. It is a wonderful opportunity for co-operative effort in the development of the engineer. Fortunately, a few industries and societies have made possible an opportunity to organize a broad program. Cincinnati, Ohio, has been chosen for the trial and the progress will be watched with interest.

THE MANAGEMENT DEVELOPMENT PROGRAM

The desirability of a program for those who have been in the company for a period of time cannot be overstressed. Westinghouse has initiated and is beginning to see the results of a Management Development Program. It was soon realized that such a program never could be fully successful without the backing of top management as a whole and the president in particular. It must be directed along the lines of securing sufficient data to help a man improve, and not to secure information for rigorous criticisms of him in his job.

This program, which applies to everyone in a supervisory position, has four definite steps. The first step is to secure a good definition of each supervisory job. This is accomplished by having each supervisor write down what he thinks his own job is. This he then discusses with his immediate superior, at which time the ideas of the two are incorporated into a description of that particular job. This step is essential so that the man realizes the standard being used to appraise him. Also, it is helpful for a member of management to know the concepts supervisors have of the functions and contents of their jobs. It establishes a clear-cut understanding of what a man is supposed to do. It is surprising how the responsibilities of a job are often defined by what the former holder of it did.

This step has been received enthusiastically as it has provided a much better definition of responsibilities through the entire line operation.

Step two is the appraisal of each supervisor by a 3-man committee on how he is performing in the light of the responsibilities now mutually understood as a result of step one. In addition, this committee prepares a statement as to what the potential of the man is and what further instruction best will help him develop. After this appraisal is completed, it is mandatory that the immediate supervisor who was one of the committee of three, discuss with the individual in detail the committee's evaluation of his performance and what he can do to improve himself so as to be ready for advancement. The criticism is constructive and the men being evaluated are enthusiastic about the program. It gives men climbing the rungs of the management ladder the pleasant satisfaction of knowing how the boss feels they are progressing. It vests them with enthusiasm to improve themselves, with the hope—but with no guarantee—of promotion.

The third step in this program is the creation of a replacement table for the entire organization, naming where possible, two replacements for each job. This inventory of management people casts the spotlight on the men who are ready for immediate advancement. Almost as important, it points up the weak spots in the organization. The chart is in color, the colors showing at a glance a man's educational background and his performance in his present job, as well as his potential for advancement. For example, too much red on the chart serves to warn the manager that it should be reviewed carefully; whereas a good showing of blue indicates strength in that particular organization.

The fourth and most important step in this over-all program is the implementation, how to help the man strengthen himself in his present position or for promotion in the organization. This is the follow-through and must be carried forward aggressively. If not, the program will come to be considered by the organization as simply a means of uncovering weaknesses and not helpful in correcting them.

In preparing the appraisal forms of step two, the committees were asked to make recommendations as to what might improve the individual both as to present performance and potential. Also, in the appraisal discussion by the supervisor and his superior it is mandatory that a man be given the opportunity to suggest what type of help he would like to have to strengthen his management ability.

A review has been made of the answers to these questions. The principal factors, listed in order of frequency, are the following. They total more than 100 per cent, of course, because some men asked for more than one type of help.

1. Guidance and counsel by supervisor, 57 per cent.
2. Training in management and management practice, 39 per cent.
3. Special and committee assignments, 20 per cent.
4. Job rotation for broadening, 17 per cent.
5. Public speaking, 12 per cent.

To satisfy the desires expressed, instruction courses are being prepared. Job rotation is being established also, switching men in engineering to manufacturing, men from sales into engineering, and so forth. Although the company has had public speaking courses for some time, further encouragement is planned for these people to avail themselves of the opportunity presented. Also, in some cases individual self-training is being recommended. A large number of men have taken the Harvard and University of Pittsburgh courses on Advanced Management.

Although the Management Development Program has been initially introduced in the supervisory group, it is our intention to have it reach deeper into the organization as soon as possible.

THE GOALS

SOME OF THE THINGS that the individual and the company can do to promote the growth of the engineer have been discussed. Here is a brief summary of the goals to which this growth can lead.

It is obvious that if engineering growth is realized, that is, if we become better and more versatile engineers, it is logical to assume that we will be of more value in our jobs and consequently will receive more personal remuneration. In addition, there are far broader horizons, which we, concerned as we are with our more immediate problems, rarely consider.

In this era of mass production, the engineer is taking an every-increasing position in the executive field. During the last decade engineers have begun crowding the bankers and lawyers in the contest for high-level administrative posts. So successful have been their efforts that an independent survey shows that one-third of the largest corporations in America, 50 out of 150, are headed by graduate engineers. The records also show that 40 per cent of those taking an engineering education end up in management positions. These figures become even more significant when one recalls that there are ten liberal arts and teachers colleges in the country for every engineering school.

We have seen that the schools, corporations, communities, and societies have one objective: to do everything possible to help the young man rapidly attain full professional stature, provided, of course, the young man realizes that he first must accept the program with enthusiasm and devote time to it. He will get out in proportion to what he puts into the program. The degree of success attained by a young man depends on many factors, but there is little chance of success, however, unless the man is enthusiastic about his job.

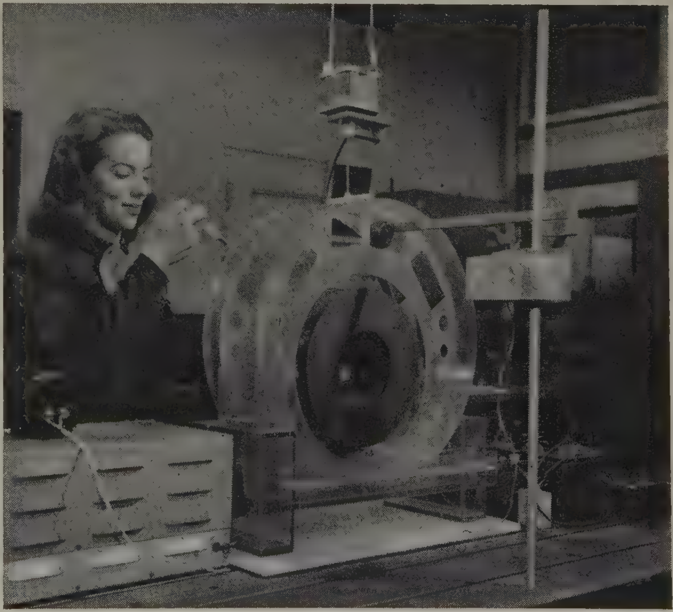
There is yet another goal, which was admirably summed up in an article in *Dun's Review* for October 1952 entitled, "Science, Wait for Us," in which this serious plea is made: "Will the engineering and kindred specialists who have made some wondrous progress in triumphing over time, space, force, microbes, atoms, and even the weather, please lend us a hand with some pressing problems in the social world on which progress hasn't quite kept pace with your advances?"

As engineers, above all people, know, we dare not wait if we are to keep pace in the United States with world competition. And we cannot in all fairness refuse to join in the common battle to understand the inventive miracles which have resulted from our professional skill. We must face up to the social implications of our technical achievements.

The answer to this professional and social challenge lies in the ability of each of us to grow. It is up to us as individual engineers to be responsible not only for our own growth, but also to encourage programs which can help our brother engineers to grow. How well we do these jobs will be decisive in plotting the destiny of our profession and our nation.

Plastic Model Aids Vibration Analysis

The young lady, shown in the illustration at right, at the Research Laboratories of the Westinghouse Electric Corporation, is demonstrating a new use for the standard medical hypodermic syringe, cementing together parts of a plastic model used for investigating effects of vibration on generators and other large electric machines before the actual units are built. The "shot" of acetone and plastic cement is injected into holes drilled through both parts to be joined.



This novel method helps insure a better job of fixing sections of the model which must withstand vibrations from the electromagnetic "driver" shown at the top of the plastic frame.

Use of the plastic model is a technique developed by Westinghouse scientists to test any large complex machinery against the effects of vibrations where it is impossible to get such information by mathematical computation. Use of a plastic model for such tests saves costly design changes in the actual apparatus.

Education and Public Policy

H. T. HEALD

In these days of uncertainty and indecision, when free peoples are struggling to maintain their freedoms, a nation's educational system can be its greatest resource. The Chancellor of New York University here discusses the future of American education and its relationship to some of the national and international problems we now face.

TODAY WE STAND on the threshold of a new era in American political history. A new administration has assumed the leadership of our national government. How it performs, the policies it pursues, the competence it demonstrates—these will have a profound effect upon the lives of all of us.

The future of American education and its continued success in fulfilling its vital function in our society are closely related to the national policies which we adopt. Therefore it is appropriate, and certainly timely, to refer in general to some of the national and international problems we now face.

The key problem in the current world dilemma is, of course, the clear-cut conflict between communism and the free world. We have hoped, after each of our wars, that it would be the last. We have prayed that we could avoid further wars. We have tried to set up means of negotiating our differences, of settling our disagreements by peaceful means.

Unfortunately, however, we find ourselves living in an age when the two major world powers have atomic weapons in sufficient quantities to annihilate each other, with all the tremendous hazards which that implies.

Even so, we need not be pessimistic about the ultimate possibilities for peace, but we would be something less than realistic not to recognize that as a nation we face a long, perhaps indefinite, period of military and economic preparedness for a conflict which we fervently hope never comes. In some ways it is more difficult to tread this tightrope of uncertainty than it would be to make an all-out war effort; to determine what is adequate for defense and at the same time to encourage the kind of climate in which a decent civilian economy can exist.

It is not too difficult to agree upon both the nature of our problem and the alternatives with which we are confronted. It is infinitely more difficult for us to agree upon the specific policies and action needed to meet our objectives. Herein is posed the major problem facing the new administration. And herein, too, are posed the special problems which face higher education and with which, in some measure, the new administration must deal.

THE PAST 20 YEARS

OUR EXPERIENCE and common sense indicate that education is a vital function in American life and that it must relate itself to the national situation that exists at any given time, or may exist in the future. There is plenty of evidence of this in the trying period of the past 20 years, for this was a time of ups and downs for education. Probably no period in history saw such peaks and valleys in its fortunes; when it was called upon to do so much; or when it has had to struggle as hard to get what it needed to do the job it had to do.

Twenty years ago the nation was in the grip of a paralyzing depression. Many may recall the efforts to relieve our distress—the emergency measures, the expansion of federal influence, the temporary agencies that stayed on and on. The depression, too, brought a decline in births, and this biological statistic brought problems all along the line as the youth of this time moved through the years of their schooling.

Then came the war period—before, during, and after—each time segment bringing a particular kind of disruption in the lives of individuals and institutions. There were war training programs, depleted supplies of professional talent, the tremendous expansion of government research in the colleges and universities, the influx of veterans which almost overnight doubled the enrollment in higher education, the beginning of a disastrous inflationary spiral, and the steadily increasing federal income taxes that dry up the sources of support for our educational system, public as well as private.

To describe these in detail would make of each an essay in itself; suffice to say that we no sooner had weathered some of these crises and had begun to get a breather when along came Korea. The nation moved into another period of increased pressures, and so did education. And it looks now as if we are in for a long period of uncertainty and indecision. We are engaged in a limited war, with all the wartime demands for people and things; yet we are expanding our civilian economy at an unprecedented rate, and that, too, means a demand for people and things. Our employment is at an all-time high, yet we are short of engineers, doctors, and other professionals. Young people are in exceedingly short supply. That low depression birth rate and our current high demand have us in a personnel vise. There simply are not enough young people to go around; to go to college, to serve in the military, to man our economy.

It is trite to say that we cannot compete with our potential enemies on the basis of numbers of people.

Essentially full text of an address presented at the general session of the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

H. T. Heald is Chancellor of New York University, New York, N. Y.

We all now believe this. What we must do is devise a policy that will make it possible for each individual to develop his greatest mental potential, to contribute the most of which he is capable, to serve his nation in the way in which he is best able. Brainpower is manpower. Educators pretty generally believe this. Statesmen should be more aware of it.

It is easy to say that the nation needs a workable, understandable manpower policy. The nation needs it; education needs it. It is not easy to arrive at, but surely we can improve upon the example of the past few years. There is high hope that the new Assitant Secretary for Defense, an experienced and able educator, will be able to make some progress in clarifying and defining our national manpower policy.

Simple arithmetic makes it clear that essentially all physically fit young men will be required to serve a stint in the military as long as our Armed Forces must be maintained at approximately their present strength. The problem, then, is not who is to serve, but when the service is to be rendered. Policies with respect to time of service, kind of service, and deferments should be clear, and they should be administered fairly. It is not fair, for example to grant a deferment for education, then permit the individual to be deferred indefinitely because of his place of employment or because he becomes a father.

Dr. Heald

If the national welfare requires it, we shall have to take more college students, fathers, and individuals in the higher age brackets. This is regrettable, of course, but the national welfare comes first now as it does in total war. The stakes are no less great. However, our manpower policies must take into account the absolute necessity of thinking not in terms of numbers but in terms of the abilities and capacities of our people. We can hardly sustain the impact of a lost generation of uneducated citizens.

Universal Military Training provides no simple answer to the current military manpower problem, nor to maintaining a state of preparedness, as long as it is necessary to require 2 years or more of compulsory service. In theory we now have universal military service, but not universal military training. In practice, military service is not yet universal, but it promises to become more so with the shrinking supply of available manpower.

For some time to come, selective service seems to be the only practical method of meeting military manpower needs. Its administration could be improved by fewer conflicting statements and less frequent warnings of possible changes in practice.

The Reserve Officer Training Corps (ROTC) program, started by the National Defense Act of 1916, has produced 150,000 officers and given some military training to 2,000,000 students. Today these units operate in 231 colleges and universities. ROTC is the most sensible and economical way for the military services to train officers. The danger is that young officers may not be assigned on the basis of educational background and ability, but on the basis of expediency.

In so large a program, for example, there is included a number of scientists and engineers; and these talents are too rare and too valuable to the country's welfare to have them wasted on assignments made without regard for the special preparation they entail. The responsibility of the military is great to use officers properly, and this obviously should be spelled out clearly and enforced rigidly in our manpower program. There is still some tendency for the military to think in terms of bodies instead of specific skills and abilities.

Personally I should like to see some of the Army and Air Force ROTC trainees carefully selected at the time they graduate from high school and paid during their college years. This is the formula of the so-called Holloway Plan for Naval ROTC, and it has worked well. Students are paid $50 a month; their tuition is paid; and their uniforms are furnished. They agree to a term of active duty longer than that required of others called upon to serve. This is a logical and relatively inexpensive method of training regular and reserve officers in large numbers.

THE GOVERNMENT AND EDUCATION

The GI Bill after World War II was the biggest bonanza that ever befell our college-age population. It was, in fact, a federal scholarship program, in which the criteria for participation included military service as well as academic ability. There has been some pressure for a peacetime federal scholarship program. This was one of the recommendations of the President's Commission on Higher Education, which estimated that 32 per cent of our high school youth are capable of completing a program of higher education.

I am sympathetic with the hopes expressed by the Commission for the education of our youth, but I reject the idea of a federal scholarship program for three reasons. First, I think we should not add more federal expenditures to our already overloaded national budget. Second, we are in effect now committed to a federal scholarship program through the second GI Bill and the ROTC program (although these do discriminate against women). Third, I still believe that scholarship aid should be handled, in general, at the local level.

One of the paradoxical aspects of the relationship between government and education in the past decade has been federal support for research. Except in agriculture, this relationship was practically nonexistent before the second World War. In 1940 the Federal Government spent $20,000,000 for research in colleges and universities; this year it is spending $250,000,000. This is paradoxical because it has been both good and bad; it has brought great benefits and it has created many problems.

It should not be forgotten that education played a major role in the winning of the war. Its scientists and engineers, working in their laboratories across the nation, were responsible for many technological developments that hastened the end of the conflict and saved thousands of human lives. Furthermore, this research, spurred on by the urgency of war, had an indirect benefit to higher education. It enabled many colleges and universities to keep the core of their research staffs intact, and it helped them over the low-income period of declining enrollment.

But the end of the war, which brought the flood of GI students, was not accompanied by a reduction in research. On the contrary, research volume continued to grow, especially after Korea. This double demand pushed the colleges to the limit to provide space and staff. Both were in short supply. And contrary to popular belief, the upswing in enrollment and research did not solve the financial problems of education. It only made them more severe, for neither education nor research in colleges and universities pays its own way. The student's tuition is less than the cost of his education, and only rarely is the overhead rate on government research sufficient to defray the total cost to the institution.

It is certainly in the public interest that the government continue to support substantial research activity in a variety of fields. Scientific and technological progress is our best assurance of keeping ahead of our potential enemies. A reduction in expenditures for research is neither a good nor a safe way to balance the national budget.

It is true that most of us in educational institutions recognize that our research is badly out of balance. Almost all of it is in the physical, engineering, biological, and medical sciences; almost none, in fact only about 3 per cent, in the social sciences and humanities.

We would like to have more research sponsored by industry, more fundamental research and less applied, and more research in the social sciences and the humanities. Again, colleges and universities are caught in the whirlpool of world events. The needs of our time, far more than the wishes of our people, whether they be educators or not, dictate the course we must follow.

Federal policy probably will change little as long as we are faced with the necessity of staying ahead in the race for world military leadership. I question the wisdom of more federal expenditures in any area where they can be reduced. However, industry does have an important stake in the kind and amount of research done in educational institutions; and industry should study carefully the benefits to itself and to society that could accrue from the sponsorship by industry of more research of a fundamental nature and more research in the social sciences and humanities.

Somehow we have lost sight of the fact that underlying all of our applied research and all of the benefits derived from it is the store of basic fundamental knowledge that must be constantly replenished. We must have this knowledge if we are to continue to make scientific and technological advancements. Government and industry both must realize this or we shall lose the advantage somewhere along the line in our struggle to maintain our freedoms. The National Science Foundation has made a start in this direction.

In the same way, we must not forget that human beings are still more important than machines. Faster airplanes, deadlier weapons, and bigger television screens seem to be necessary to our way of life these days; but, in the final analysis, their value is small compared to human understanding and the brotherhood of man. The great truths of our time are intangible but nevertheless real, and they must be renewed and revitalized by each new generation.

THE FREEDOM OF EDUCATION

A MATTER OF supreme importance to the new administration, and to all of us, is the place of education in a free society. We are concerned not merely with producing people who are versed in specific skills valuable to our economic and military life, but also, and more importantly, people who are able to understand and deal with political and social problems nationally and internationally.

To do this, it is essential that we maintain an educational system and a society in which ideas can flow freely from one person to another. If we really believe in freedom, then we must maintain our own free institutions so they can perform their proper functions and make the contributions that can be made only in an atmosphere of freedom.

Every totalitarian government has tried to control education, because, with control of thought, everything else can be controlled. Communists know this, of course, and they have tried to infiltrate our educational institutions. In a small minority of cases, they have been successful. We have been slow to recognize this and to protect ourselves, because, in our zeal to maintain academic freedom, we sometimes have failed to root out those who believe in it the least.

As educators, we suffer from two conflicting dangers. On the one hand, there are those persons, some in influential positions, who tend to attribute traitorous motives to anyone who disagrees with their way of thinking. On the other hand, there are many sincere and equally loyal Americans who are concerned because they are unable to see how academic freedom can be maintained if any restrictions whatever are imposed upon the teachers.

The basic problem in both quarters is a lack of understanding. The American people generally are committed to a policy of academic freedom in their educational institutions, and almost all of them want to achieve it, at least in the abstract. There is little, if any, difference of opinion as to the basic objective; there is a vast difference of opinion as to method of achieving the objective. The reason for a reverent adherence to the principle of academic freedom is not that it provides a privileged environment for scholars or students, but because it maintains the basic freedom of thought and action essential to an unregimented society. But the maintenance of academic freedom does not require communists on a university faculty.

It has been clearly demonstrated that a member of the Communist Party is not a free agent, intellectually or politically. He is not the same as any other person expressing an unconventional opinion. He cannot claim academic freedom because he has forsaken the principles of academic freedom. He is restricted to a line of thinking and action dictated by a foreign power.

Some persons believe today that anyone who advocates a point of view that happens to coincide with the Communist Party line is a communist. This is simply not true. Take racial or religious discrimination for example: the communists say they are against it, but their actions indicate that they simply have used this device to try to gain the support of liberal-minded citizens.

Now let us take the other side of the coin. Some liberals are running around these days saying that the country has become hysterical, that we are the victims of a witch hunt, that our freedoms are being rapidly eroded away. Some of our intellectuals are making comments that seem unconscionable. Somehow they feel that their eminence in one field makes them expert in all fields. Of course a tense international situation produces stresses and strains at home, but there is little evidence that our civil rights are disappearing. The courts have been scrupulously fair in their interpretations of our civil rights laws and in the decisions on cases brought before them.

Elected representatives to the Congress, both in the Senate and in the House, have indicated that they now intend to investigate subversion in the nation's colleges and universities. It is obvious, of course, that responsible educators will co-operate with any properly constituted committee of the federal Congress in helping its members carry out an appropriate investigation. It is just as inappropriate to issue blanket condemnation of investigating committees as it is for the members of such committees to make irresponsible charges against individuals or institutions they may suspect of wrong actions.

The problem posed by any such investigations is a difficult one at best. They can be useful only if approached in the most careful manner with every desire to reach fair and equitable decisions.

As the new administration moves into office, it is to be hoped that its policy on education will not be one that inadvertently burns down the barn to get rid of a few rats in it. Our educational system is the nation's greatest resource. Upon it depend the stability of our economy and the perpetuation of our political system. Let us not destroy these things with reckless and unthinking action. Let us, rather, work together—educators, legislators, businessmen, and all citizens—to preserve our free educational system.

Pocket-Sized Instrument Tests Bazooka

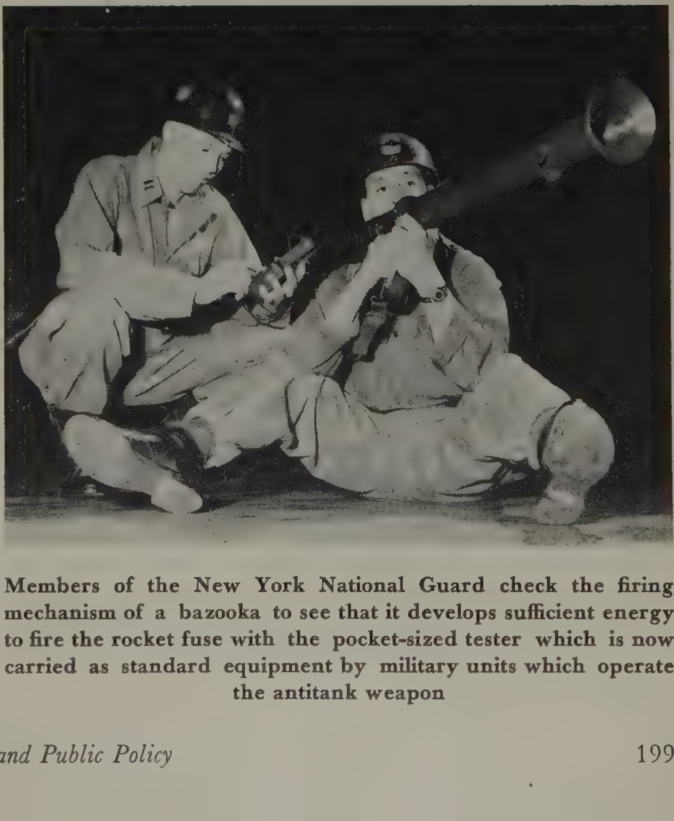
A pocket-sized instrument, produced by the General Electric Company, is aiding proper operation of the United States Army's famed antitank weapon, the bazooka.

Called a "bazooka tester," the device is used by soldiers to check the firing mechanisms of the rocket-launching weapons before they are placed in action. It is carried as standard equipment by the various military units which operate bazookas.

The specially designed portable instrument indicates faulty firing mechanisms which do not develop sufficient electric energy to fire the fuse of a rocket.

Originally developed by the United States Rock Island Arsenal, Iowa, the bazooka tester was transferred to General Electric for improvement and manufacture.

The device consists of a conventional indicating panel-type instrument that is operated by the output from a vacuum-type thermocouple. The firing mechanism of the bazooka develops energy from a flip-flop magnet inside an induction coil, and this energy is used to fire the fuse of the rocket. In testing the firing mechanism, the energy is dissipated into the vacuum thermocouple where it is indicated in millivolt-seconds.



Members of the New York National Guard check the firing mechanism of a bazooka to see that it develops sufficient energy to fire the rocket fuse with the pocket-sized tester which is now carried as standard equipment by military units which operate the antitank weapon

Air Pollution Prevention

H. A. BAUMAN
MEMBER AIEE

Air pollution prevention has been a concern of the electric power industry for many years. This article brings together and evaluates considerable data concerning this problem, placing special emphasis on electrostatic precipitators.

ELECTRICITY is a necessity in modern living, but very few cities and large industrial centers are so situated that adequate electric power can be obtained without the aid of fuel-burning power stations. Water power is today the only nonfuel source for electric power; coal, oil, and gas are the fuel sources. The combustion of fuel of any kind—solid, liquid, or gaseous—always results in waste products that must be disposed of. Carbon dioxide and water vapor when vented to the open air and adequately diffused are harmless and not objectionable although sometimes an uninformed public sees a plume of steam formed by the condensation of water vapor and assumes that it is an objectionable pollutant. Solid particles are always found in the waste from the furnace burning fuels. They may range in size from the tiniest specks too small to be seen in the most powerful optical microscope to particles large enough to be picked up with the fingers; they may range in quantity from an amount so small as to be undeterminable by even the most sensitive methods of direct weighing to amounts easily weighed. At one end the concentrations are so small as to be unobjectionable; at the other end they may create a real public nuisance.

The electric power industry has recognized for many years that it has an obligation to the public which it serves to reduce the discharge of objectionable wastes into the atmosphere as much as is technically and economically practicable. To this end it has spent millions of dollars for the installation of equipment to remove a very large portion of the dust carried by the flue gases before the gases enter the stack. It has also spent large amounts of time and effort, measured in additional millions of dollars, to obtain the most suitable fuel and fuel-burning equipment and to operate it in the most effective way to reduce air pollution. The present article aims to bring together and place in its appropriate relationship a considerable mass of data, with particular emphasis on electrostatic precipitators.

BOILERS

Combustion Must Be as Complete as Possible. A basic requirement in air pollution prevention is that the burning of the fuel must be as complete as practicable to minimize the amount of combustible materials, or partially burned particles, entrained by the flue gas to be removed by dust-separating equipment.

The fuel must be properly prepared, intimately mixed with air, and so introduced and burned in furnaces of adequate design to insure almost complete combustion. Fuel-air ratio must be correctly maintained at all times. Ample fan capacity must be provided so as to maintain the correct amount of excess air. Detectors of the light-beam type which are installed in the boiler flue have proved very useful for quickly signalling faulty furnace conditions to the operators.

The Effect of Ash in the Fuel. The percentage of ash in the fuel is important because the quantity of fly ash entrained by the boiler gas stream which must be treated by the dust-separating equipment is related to the amount of ash in the fuel. Higher ash fuels increase the duty on the dust-separating equipment and result in increased stack discharge for the same collector efficiency.

Slag-bottom furnaces drain off a portion of the fly ash in fused form, while other types of furnaces separate out varying proportions of the fly ash particles in solid form from the flue gas stream, before the entrained fly ash reaches the mechanical collecting or electric precipitation equipment. The use of fuels of low solid residue, such as natural gas, results in very low flue gas dust loadings, if completely burned.

ELECTROSTATIC PRECIPITATORS

THE ELECTROSTATIC PROCESS of fly ash removal is based on the fact that electrically charged particles experience mechanical forces when placed in an electric field. An electric discharge from the high-voltage wire electrodes is used to charge fly ash particles which are then forced to collect or precipitate on the surface of the collecting plates. Fundamentals of precipitator operation have been described in detail by White[1] and by Schmidt and Anderson.[2] A wiring diagram of an electrostatic precipitator is shown in Figure 1. A method of measuring the voltage on the discharge electrodes is included in this diagram.

The Effect of Voltage and Power on Precipitator Efficiency. Our tests indicate that it is of utmost importance to maintain the highest possible peak voltage on the discharge

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Full text of paper 53-27, "Air Pollution Prevention in Electric Generating Stations," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Operations Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Not scheduled for publication in AIEE *Transactions*.

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electrodes to charge effectively the fly ash particles and hold them on the collecting plates. Figure 2 shows that driving the rectifier sets at higher ratings increases the output voltage. Adequate transformer and rectifier capacity must be provided. The importance of high voltage is further illustrated by Figure 3 from which it can be seen that precipitator efficiency increases appreciably with voltage. It should be noted that at 35 kv the efficiency was 86 per cent, while at 40 kv it was 93 per cent; this represents a reduction of 50 per cent in stack discharge.

The power input to a precipitator should be designed to be as large as possible to sustain the high voltages and consequently the high-intensity electric fields necessary for high efficiency. In order to obtain high efficiencies, mechanical rectifier transformer capacities in the order of 40 kva per 100,000 cubic feet per minute of flue gas going through the precipitator are often used. The actual power input to the precipitator electrodes may be in the order of 9 kw per 100,000 cubic feet per minute of flue gas for 97 per cent efficiency. Still higher power inputs should be considered in order to obtain higher efficiencies. Also, a greater degree of precipitator bus sectionalization is essential in order to confine faults to a small portion of the precipitator.

To prevent unnecessary tripping out due to momentary overloads of the rectifier sets when they are being operated at full capability, overcurrent protection should be provided which will have sufficient time delay to avoid tripping during short periods of arcing in the precipitator, and yet will be sufficiently fast to prevent overheating of the equipment due to sustained overloads. Properly selected time-delay fuses in the low-voltage supply circuit may be used for this purpose.

Automatic voltage control, based on the maintenance of an optimum sparking rate, say 100 sparks per minute per section, offers a means of continuously maintaining high efficiencies.

It has recently been shown by White[3] that higher precipitation efficiency is obtained by the pulse system of energization because still higher peak voltages can be used without arc-over in a precipitator.

The Effect on Efficiency of the Ratio of Collecting Area to Gas Flow. A fundamental relation in precipitators is the ratio of the effective area of the collecting plates to the flue gas flow through the precipitator. Ratios in the order of 8 to 9 square feet of surface per cubic foot per second of flue gas are used for 97 per cent precipitator efficiency. Figure 4 illustrates the relation between this function and precipitator efficiency. Another useful factor is called the "time of contact." It is the time in seconds that the flue gas remains in the active field of the precipitator. This factor is of less fundamental importance than the afore-mentioned collecting area–flow ratio.

High Gas Velocities Must Be Avoided. Gas velocities going through a precipitator generally range from 5 to 10 feet per second. Low values of gas velocity, from 5 to 7 feet per second, are used for high efficiency in order to avoid the re-entrainment of collected particles from the collecting plates.

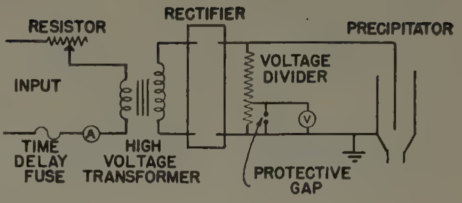

Figure 1. Wiring diagram of precipitator showing how the voltage of discharge electrodes is measured

Any operating condition which causes an increase in the flue gas velocity through a precipitator decreases efficiency. Boiler air leakage must be kept to a minimum. Uniform gas distribution entering the precipitator must be maintained. The serious effect of nonuniform gas velocity may be realized when it is noted that relatively large portions of the gas may pass through a small area of the precipitator at high velocity and result in poor over-all efficiency. This effect is also related to the entering-duct and to a lesser extent to the exit-duct design.

Low Combustible in Fly Ash Improves Precipitator Efficiency. With good combustion conditions the combustible content of fly ash may range from 2 to 8 per cent. Our tests show that precipitator efficiency is substantially reduced when the combustible content of fly ash exceeds 10 per cent. Figure 5 illustrates the rapid decay of efficiency with increased combustible content.

Microscopic examination of flue gas particles containing a high percentage of combustible reveals a much greater number of large or + 44-micron (325 mesh) size particles. These coke particles are large, irregular, and porous. It is these particles which are so easily re-entrained by the gas

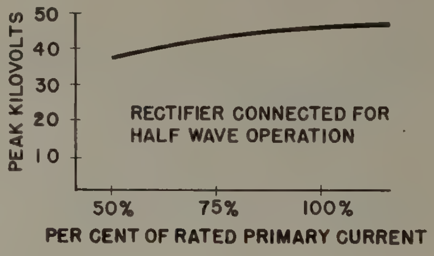

Figure 2. Effect of operating rectifier sets at higher ratings

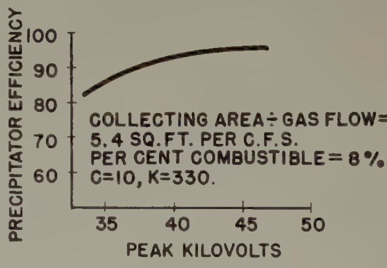

Figure 3. Effect of voltage on efficiency

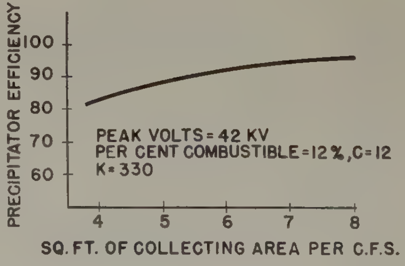

Figure 4. Effect of precipitator collecting area on efficiency

stream, particularly at high velocities, and which result in much lower collection efficiency for these particles in the electrostatic process. Another type of easily re-entrained material is the large agglomeration of fused particles produced in some boiler furnaces.

Re-entrainment of the large coke particles or the agglomeration of fused particles will be reduced by decreasing the gas velocity. Another method is to install shielded or pocket collecting plates, which shield the particles from the scouring action of the gas stream by providing vertical shielded paths to the precipitator ash hoppers.

The reduction of high combustible content in fly ash is a problem of furnace and burner design and operation and is important in order to improve precipitator efficiency and fuel economy and to make possible the use of fly ash for the growing industrial market.

Prevention of Current Leakage Paths. Fly ash bridging over between the discharge electrodes and the collecting plates must be prevented or it will result in the formation of current leakage paths. Such leakage paths will result in lowered efficiency because of lowered voltage and also because much of the available current will be drained into these short-circuiting paths instead of going into the particle charging and precipitation process.

Practically all dusts can be removed from the electrodes by proper vibration. Continuous rapping with blows of carefully controlled intensity is a very satisfactory solution to the difficult problems of maintaining optimum electrical conditions in the precipitator and of eliminating the stack puffs associated with intermittent rapping methods.

Frequent inspections must be made for broken electrode wires, unequal plate spacing, defective insulators, and fly ash accumulations. Rapping or scraping equipment must be properly maintained so that deposits of fly ash on the collecting plates will be reduced to a minimum. Precipitator plates and electrodes must be kept clean to prevent arc-over. Any defective precipitator section should be cut out as it is generally better to operate with a bad section cut out than to operate at reduced voltage on a number of sections. Fly ash hoppers must be emptied at frequent intervals to prevent short circuiting of the electrodes. Moisture condensation must be avoided. Freshly precipitated fly ash is very fluid, but when cold there is a packing tendency. Hence it should be handled in a warm condition.

Electrical Resistance of Fly Ash. The electrical resistance of fly ash has been found to be important in electrical precipitation. High ash resistivity above 2×10^{10} ohm-centimeters causes severe sparking to occur at relatively low discharge electrode voltages resulting in lowered efficiency. The presence of small amounts of sulphur compounds, such as sulfur trioxide (SO_3), in the flue gas lowers the resistivity of the fly ash. With the bituminous-type coals used on this system, this high-resistivity problem has not been encountered.

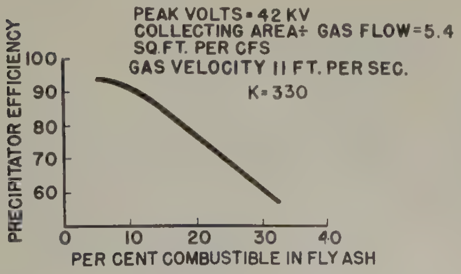

Figure 5. Effect of combustible in fly ash on efficiency

Precipitator Efficiency. The basic law of electrical precipitation efficiency was discovered experimentally by Anderson[4] and was further developed by White.[5,6] It has been found from tests made by Consolidated Edison Company of New York, Inc., that it is possible to express the theoretical relation in a form which brings out the practical operating factors.

The efficiency N of a precipitator expressed as a decimal is

$$N = 1 - 1/e^x$$

The value of the exponent x may be approximately determined empirically as follows:

$$x = AE^2/VCK$$

where A = effective collecting electrode area in square feet; V = gas flow through precipitator, in cubic feet per second; E = peak voltage, in kilovolts; C = a re-entrainment factor which is closely related to the percentage of low-density coke particles, agglomerations of fused particles, gas velocity, and type of collecting plates; K = a constant for a particular precipitator; and e = 2.7 (natural log base).

It should be noted that when the value of the exponent x is equal to 4, the efficiency of a precipitator is 98 per cent. Very high precipitator efficiency is possible, but complete elimination of all stack discharge is technically and economically impractical.

The efficiency of a precipitator is not appreciably affected by ranges of dust loading normally encountered in properly designed and operated boiler furnaces.

The value of E^2 is closely related to the power input to the precipitator.

MECHANICAL COLLECTORS

MECHANICAL COLLECTORS of the centrifugal type have proved their worth on stoker-fired and on pulverized-fuel boilers. In some multicyclone (small-diameter cyclones) collectors, the gas is brought in at the top of the separating tube and then is made to whirl by vanes positioned in the path of the incoming gas. This design uses a very large number of small-diameter tubes resulting in high centrifugal forces acting on the particles in the flue gas. The draft drop in a multicyclone collector is in the order of 2 to 3 inches of water. With this equipment, efficiencies of 95 per cent and over are obtainable with particles of 25-micron size or larger. The efficiency with smaller size particles falls off rapidly as illustrated in Figure 6.

Another type of centrifugal collector consists of a large number of hollow-steel cones, each more than 10 feet high. The cones are installed so that gases leaving the boiler will enter the large end of the cones and pass through some 2,000 slotted perforations in the sides, leaving the fly ash particles inside the cones where they are removed by an auxiliary vacuum ash-collecting system. This system has the advantage of a low draft drop of about 1 inch of water which is important when it is necessary to add a mechanical collector to an existing precipitator installation. Wear from dust erosion on the slotted perforations presents a maintenance problem. Adequate rapping mechanisms must be used to rap the hollow-steel cones to prevent plugging.

COMBINATION MECHANICAL COLLECTORS AND ELECTROSTATIC PRECIPITATORS

CENTRIFUGAL COLLECTORS have relatively higher resistance to gas flow than electrostatic precipitators which helps to establish more uniform gas flow patterns when they are placed ahead of the precipitator. Centrifugal collectors also help to prevent stratification in the fly ash content of the gas entering the precipitator. In the case of mechanical collectors, the energy for dust removal must come from the boiler fans, while in the case of electrostatic precipitators, the energy for particle collection comes from the power supplied to the precipitator.

Combinations of mechanical collectors and electrostatic precipitators offer substantial advantages. A mechanical collector having an efficiency of 75 per cent in series with an electrostatic precipitator having an efficiency of 96 per cent will result in an over-all collecting efficiency of 99 per cent if the equipment is properly maintained.

STACK DESIGN AND OBSERVATION

STACK DESIGN is important because much can be accomplished by better diffusion of the gases into the atmosphere. Stack design is concerned with height and diameter of the stack and it is particularly concerned with the "effective height" which may be increased by suitable changes in the shape of the top of the stack and by increasing the exit velocity of the waste gases. Such stack designs can appreciably reduce the concentration of pollutants at the ground level or at surrounding structures as shown by Davidson.[7]

Equipment failure may result in objectionable stack discharge which might continue if undetected. Stacks are watched by stack observers whose sole duty is to report any improper stack condition to the operators for immediate correction. Stack monitoring by television is also used at Consolidated Edison's Waterside station.[8]

THE MEASURE OF POLLUTION

THE ELECTRIC GENERATING STATIONS in New York burn about a third of all fuel used in the city, but contribute only a small percentage of the total air pollution, because of the extensive preventive measures taken.

Pollution is most often measured by the quantity of dust, that is, solid particles, that are collected in an open-mouth jar or can placed at some convenient spot. In such a measure, a single piece of cinder or coke may weigh more than many thousands of submicroscopic particles.

On the other hand, if the measure is the obscuring effect of the particles as dispersed in the gases leaving the stack, the large particles may be rated, if they are noticed at all, as quite unobjectionable while the minute particles will be rated as very objectionable. As another example, we may consider the effect of clouds formed by condensation of water vapor in the flue gases. Whether the vapor came from the evaporation of water entrained in the fuel or was formed in the furnace by a chemical reaction between hydrogen in the fuel and oxygen in the air, few would argue that it should be treated as a pollutant. Yet many of these same people will assert most emphatically that the stack discharge is objectionable because they could not "see through the plume."

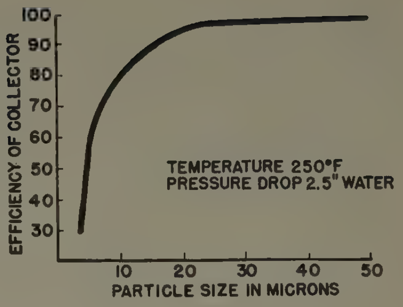

Figure 6. Mechanical dust collector functions with fractional efficiency on smaller particles

In the measurements of dust collector performance, we have followed the usual practice used by power plant engineers of expressing performance in terms of the efficiency *N*. Actually we are most interested in what leaves the stack and the measure of that is 1-*N*.

CONCLUSIONS

1. A basic requirement in air pollution prevention is that the burning of the fuel shall be as complete as practicable to minimize the amount of combustible materials, or partially burned particles, to be removed by either the mechanical-collecting or the electrical-precipitation equipment.

2. It is of utmost importance to maintain the highest possible peak voltage on the electrodes of electrostatic precipitators. The power input to a precipitator should be as high as possible so as to sustain the high voltages necessary for high efficiency. Mechanical rectifier transformer capacities in the order of 40 kva per 100,000 cubic feet per minute of flue gas are often used. A greater degree of precipitator bus sectionalization is essential to confine faults to a small portion of the precipitator.

3. An important relation in precipitators is the ratio of the effective area of the collecting plates to the gas flow through the precipitator. This ratio should be made as large as economically practicable to obtain high efficiencies. Ratios in the order of 8 to 9 square feet of surface per cubic feet per second of flue gas are used for 97 per cent precipitator efficiency.

4. To avoid the re-entrainment of collected particles from the precipitator collecting plates, low values of gas velocity—under 7 feet per second—are often used. Any operating condition in the boiler, such as air leakage, which causes an increase in flue gas velocity through a precipitator decreases efficiency. Uniform flue gas distribution entering a precipitator must be maintained.

5. Precipitator efficiency is substantially reduced when the combustible content of fly ash exceeds 10 per cent. Microscopic examination of flue gas particles containing a high percentage of combustible reveals a much greater

number of large or + 44-micron (325 mesh) size particles. These coke particles are large, irregular, and porous. It is these particles which are so easily re-entrained by the gas stream, particularly at high velocities, and which result in much lower collection efficiency for these particles in the electrostatic process unless shielded or pocket-collecting plates are used. Another type of easily re-entrained material is the large agglomeration of fused particles produced in some boiler furnaces.

6. The combination of mechanical collectors and electrostatic precipitators offers substantial advantages. A mechanical collector having an efficiency of 75 per cent in series with an electrostatic precipitator having an efficiency of 96 per cent will result in an over-all collecting efficiency of 99 per cent if the equipment is properly maintained.

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Steppingstones to Good Industrial Relations

J. S. GRACY

With the development of big business, the close personal relationship which formerly existed between employer and employee has evolved into a complex industrial relations problem which jeopardizes the future of the American system of competitive enterprise. The successful solution of this problem calls for sincere co-operation on the part of management, employees, and organized labor.

DURING THE PAST 3 DECADES there has been greater change in our industrial relations than during any similar period in the history of the United States. In order to understand this new relationship better, let us look for a moment at the fundamental causes of the changes which have taken place:

1. The development of "big business" employing hundreds and thousands of workers, as compared with the small individual plants or stores, has almost eliminated the close personal relationship which existed between the employer and the employee when the "boss" knew each of his employees by his first name.

2. Mass production has destroyed the pride in craftmanship which the worker had when he performed all or a very large part of the work on the finished product.

3. Collective bargaining has become established by our representatives in the Congress as the proper method of determining such matters as wages, hours, and other conditions of work.

4. Union organizational activity, in many cases, has set worker against management; labor against capital; even worker against worker; and has created a gulf of fear, suspicion, and distrust in what was once a "big happy family."

5. Social legislation such as the Fair Labor Standards Act, the Fair Employment Practices Act, Social Security, unemployment compensation, and the like, have been enacted which vitally affect industrial relations.

6. During this period we have fought two World Wars with the worst depression of modern times sandwiched in between, and now we have the "police action" in Korea. With these have come disruptions of our political, social, and economic life.

Recognizing these changed conditions, we must give serious thought to the responsibility of the employer, the employee, and organized labor in solving the complex industrial relations problem, for upon the successful solution of this problem lies the hope of the competitive

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Essentially full text of a conference paper presented at a session on Management during the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952.

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enterprise system and the future of American leadership in world affairs.

The subject of this article was suggested by a poem which reads:

> Isn't it strange that Princes and Kings
> And clowns that caper in sawdust rings,
> And just plain folks like you and me
> Are builders for eternity?
> To each is given a bag of tools,
> A shapeless mass and a book of rules,
> And each must make, ere life is flown,
> A stumbling block or a steppingstone.

MANAGEMENT

MANAGEMENT CAN BEST BUILD steppingstones through providing the setting and atmosphere for good industrial relations by putting human relations ahead of everything else. Henry Ford, II, who has made an outstanding contribution towards improved industrial relations, has stated that "if we can solve the problem of human relations in industry, I believe we can make as much progress towards lower costs (production) in the next 10 years as we made in the last quarter century through the machinery of mass production."

Human relations is simply the practical application of the Golden Rule: "Whatsoever ye would that men should do to you, do ye even so to them." A variation of that Rule which should be the basis for the employer-employee relationship is, "Men dealing fairly with men."

After an atmosphere of good will and fair play has been created, what then are some of the steppingstones towards good industrial relations that management can build?

Stone 1. Recognition. The employee wants to be treated as a human being, not as a number or a piece of machinery. He wants the sense of human dignity that comes from knowing his work is useful to the organization and to society as a whole. He wants to feel important; he wants someone to tell him he has done a good job. He wants a pat on the back when it is deserved.

Stone 2. Opportunity for advancement. Promotions always should be made from within an organization whenever possible. Promotion of present employees is so often overlooked or passed over, with the idea that it is so much easier to leave them where they are and employ somebody from the outside to take over the new job. Employees should know that, if they will prepare themselves for the next job ahead and be ready for promotion when the opportunity arises, they will be given every consideration for promotion at that time.

Stone 3. Job security. It has been said that "steady employment" is a prime consideration to ten times as many workers as "high pay" and to 25 times as many workers as "short hours." At any level of employment the feeling of insecurity will affect the efficiency of the employee more than any other one factor.

Stone 4. Effective wage and salary administration. It is highly important that pay scales be watched very closely and that real consideration be given to the proper pay for each job classification and employee. Unequal compensation for employees performing the same duties causes more employee dissatisfaction than the actual wage or salary itself. Salary administration is probably one of the most difficult of management's problems, but recognizing it as such and giving it the proper attention will go a long way towards solving it.

Stone 5. Acceptance of collective bargaining in the proper spirit when a majority of the "rank and file" employees chooses to designate a bargaining representative. More than a decade has passed since collective bargaining was adopted by the legislative representatives of the American people giving employees the legal right to select an agency to represent them in bargaining with their employer. It does not do any good for management to resent the procedure. Of course, the unions, in many instances, have not done their part towards building good industrial relations. However, continual controversy will not solve the problem and the employer should be the one to take the lead toward arriving at a satisfactory solution.

THE EMPLOYEES

WHAT ARE SOME of the steppingstones towards good industrial relations that employees should build?

Stone 1. A sincere desire to do a good job. "Pride in workmanship" which prevailed when the workman produced a completed article has been lost to a very large degree in the mass production process where each workman performs only a minor function in the production of the completed article. This pride in workmanship can and should be reinstated. The famous story of the three stone masons illustrates the point. Upon being asked what they were doing, the first mason replied, "I am laying stone." The second mason replied, "I am earning $16 a day." The third mason, with his chin a little higher than the rest perhaps, replied, "I am building a great cathedral." Thomas Carlyle has said, "The glory of a workman, still more of a master workman, that he does his work well, ought to be his most precious possession."

Stone 2. A willingness to do an honest day's work for an honest day's pay. Experts in the field of industrial production report an alarming decrease in worker efficiency during the past 10 years. Better training, more efficient machines and methods, and better utilization of electric power have all contributed to greater production, but the real answer lies in the willingness of the American workman to put forth his best effort. Only with greater production come decreased costs and improved standards of living.

Stone 3. A real interest in the welfare of the employer's enterprise and a desire on the part of the employee to do his part in promoting its advancement. The workers need a better understanding of the profit system and, once it is understood thoroughly, they undoubtedly will do more towards the success of the enterprise. The American system, recognizing the freedom of individual enterprise, has resulted in more in the terms of human welfare than has any other system in the history of mankind. With only 1/16 of the world's population, we produce 7/16 of all the world's goods and services. We have 46 per cent of the world's electric power, 60 per cent of all the telephones, 80 per cent of the automobiles, 42 per cent of the radios, and 54 per cent of the refrigerators. Is it not strange that with all this proof of the success of the American system there are still those among us who want to exchange it for some other?

ORGANIZED LABOR

WHAT, THEN, ARE some of the steppingstones towards good industrial relations that organized labor should build?

Stone 1 to be built by organized labor is the acceptance of reasonable regulation. The unions have "grown up" and no longer need the kindergarten protection and favoritism which they received under the early labor laws. No one will argue that there is any balance of power in favor of the employers when it comes to economic strength in collective bargaining, particularly when men in high official positions have seen fit to throw the strength of the federal government on the side of the union. It is a little difficult to understand why the labor unions have labeled the Taft-Hartley law as a "slave labor act." Some revisions undoubtedly should be and will be made in this law, but, by and large, its provisions are reasonable and, without partisan governmental intervention, will go a long way towards providing workable collective bargaining. Laws in themselves cannot produce good industrial relations, but somehow there must be established between management and labor a spirit of good will and understanding and a mutual respect by each for the rights and responsibilities of the other. Labor must do its part.

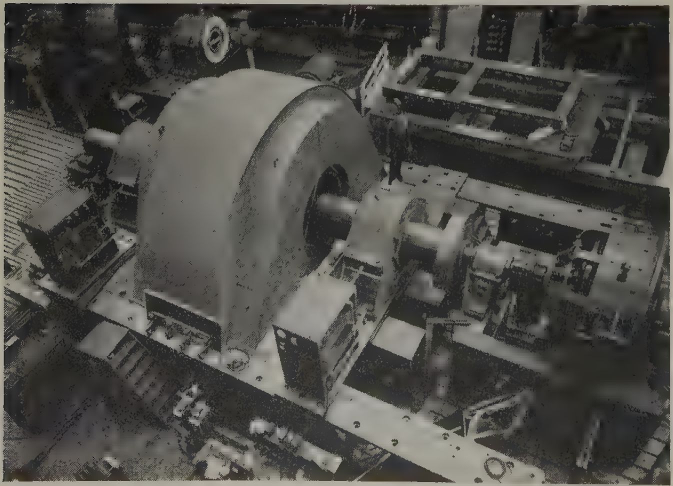
Stone 2. Bargain in good faith. The Taft-Hartley Act says that "to bargain collectively is the performance of the mutual obligation of the employer and the representatives of the employees to meet at reasonable times and confer in good faith with respect to wages, hours and other conditions of employment. . . . " A labor leader recently said, "The basis for all human relations is trust and confidence." When all responsible representatives of labor and management can discuss their problems with "trust and confidence," in the spirit of "men dealing fairly with men," we will have built an important steppingstone towards better industrial relations.

Stone 3. Put its own house in order. Organized labor should purge itself of all communists and their kind who are sworn enemies of the American form of government and all that it stands for. Organized labor should discredit its radical leaders and replace them with leaders who have not only the interest of the union at heart, but who also have a decent respect for the public good and for the welfare of the country. Organized labor should provide some means to settle peacefully among themselves their own disputes relative to jurisdiction and representation without resorting to strikes.

Stone 4. Give up the idea of restricting production by unreasonable work restrictions, by slow down, by featherbedding, and the like. Unions should accept technological advances in production equipment and techniques which, historically, have produced more and better jobs, increased production, and played a large part in improving the standard of living of our American people.

If, then, in an atmosphere of "men dealing fairly with men," management will build steppingstones of recognition, opportunity, job security, good pay, and acceptance of collective bargaining in the proper spirit; if employees will build steppingstones of a sincere desire to do a good job, an honest day's work for an honest day's pay, and a genuine interest in the welfare of the employer's enterprise; and if organized labor will build steppingstones of accepting reasonable regulation, bargaining in good faith, putting its own house in order, and eliminating unreasonable work restrictions, the path leading to good industrial relations will have been made much easier, the system of free competitive enterprise much more secure, and America's continued leadership in world affairs assured.

World's Most Powerful Motor Built for Driving Wind Tunnel



This 83,000-horsepower motor, the most powerful motor ever built, is one of two which is being completed by the Westinghouse Electric Corporation for the United States Air Force. The motors will be used for driving the wind tunnels of the Air Force's Arnold Engineering Development Center, at Tullahoma, Tenn. The two large motors will be coupled with two 25,000-horsepower motors. The four motors will form a 216,000-horsepower drive for the compressors for the supersonic and transonic wind tunnel. The entire assembly of four motors will be the largest rotating machine ever built. Shown at left is the 83,000-horsepower motor during completion of tests which are being conducted at the East Pittsburgh, Pa., plant of the Westinghouse Electric Corporation. This motor stands $21^1/_2$ feet and weighs 225 tons.

Vladimir K. Zworykin—Edison Medalist for 1952

The Edison Medal for 1952 has been awarded to Vladimir K. Zworykin of the RCA Laboratories Division, Radio Corporation of America, "for outstanding contributions to the concept and design of electronic components and systems." The Medal, awarded annually by the AIEE Edison Medal Committee, is for meritorious achievement in electrical science or electrical engineering or the electrical arts.

The Edison Medal

J. F. CALVERT
FELLOW AIEE

IN 1904 A GROUP of friends and associates of Thomas Edison banded together to form The Edison Medal Association. They desired to celebrate the accomplishments in the art of electric lighting made during the preceding quarter of a century which they felt should remain imperishably identified with the name of Thomas Alva Edison. To commemorate his achievements they established an award "to serve as an...incentive to scientists, engineers and artisans...." This association of friends asked the AIEE to administer the award. The Institute accepted and, from its own membership, established the Edison Medal Committee of 24, the sole purpose of which is to carry out this trust. Each year this group studies the accomplishments of those great contributors to the advancement of the electrical art who are residents either of the United States or Canada, and from among these selects the new recipient.

In this regard, two recent changes have been made affecting the operation of the committee. Early last year all of the Institute Sections and the various technical program groups were invited by the Edison Medal Committee to suggest the names of men who should be considered for this award. The response was good, and we believe that this procedure should be continued, since it makes the nominations even more the responsibility of the entire membership of the Institute. The second change, originally announced at the 1952 Summer General Meeting, is that during the past year the General Electric Company made a substantial gift to the Institute for the purpose of supplementing the funds provided by the early friends and associates of Thomas Edison. This second gift again makes the operation of the committee entirely self-sustaining.

Having briefly summarized these two changes of the past 12 months, we should consider the character of the award itself. A review of the names of past recipients always will call to mind a great pattern of achievement which is in accord with the best hopes expressed by those early associates of Edison. There have been scientists, engineers, and inventors like Whitney, Lamme, and Armstrong; and architects of great power and communication systems like Sporn and Blackwell. Over the years there has been formed a long list of recipients. Each of these recipients has envisioned and then sculptured something vitally new from the monolithic (or granite-like) unknown of the physical world.

During the latter part of the last century, Thomas Edison gave to man a new and better source of illumination for home and for street and factory. This year the Edison Medal honors the 42d recipient, a man who has made many contributions to radiocommunications and who is a pioneer of modern television. The Edison effect provided background for tube developments which he employed. In television Dr. Zworykin used a point of light to paint pictures in the twinkling of an eye which may serve to illuminate the minds of men. In honoring Dr. Zworykin we link the past with the present and with the future, and in so doing commemorate the creative genius of Thomas Alva Edison.

The Edison Medalist

E. W. ENGSTROM
FELLOW AIEE

I AM BOTH PLEASED and honored to have a part in this program of recognition of Vladimir K. Zworykin—pleased because Zworykin and I have been together as friend and associate for more than 20 years—honored because the Edison Medal ceremony is a profound reminder of meritorious achievement.

Vladimir Zworykin was born in Russia, not far from Moscow, in 1889. Even at an early age he demonstrated an interest in things electrical and, during school vacations, was entrusted with the maintenance of the signalling system on the river boats of his father's steamship line. His life was given definite direction by his contact with Boris Rosing, during attendance at the Petrograd Institute of Technology. In 1910, young Zowrykin went to assist

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Full texts of the presentation and acceptance addresses given at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

J. F. Calvert, chairman of the Edison Medal Committee, is chairman of the Electrical Engineering Department, Northwestern University, Evanston, Ill.

E. W. Engstrom is vice-president in charge of research, RCA Laboratories Division Radio Corporation of America, Princeton, N. J.

Rosing in his private laboratory in the basement of the Artillery School in St. Petersburg. There he caught Rosing's enthusiasm for a system of television based on the deflection of electron beams, freed from the limitations of mechanical devices. Rosing himself did not carry his ideas beyond a paper draft of a rudimentary form of cathode-ray tube receiver. His pupil, however, never lost sight of the goal up to its final and complete realization—television as we know it today.

The first few years after Zworykin's graduation in 1912 and his subsequent studies with Paul Langevin in France could scarcely have been more discouraging. The First World War claimed his talents as an officer in the Russian Signal Corps. With the termination of the conflict Zworykin sought to build up a laboratory for testing his ideas under the sponsorship of the Russian Marconi Company. The turbulence of the times and his eventual flight to the United States in 1919 nullified the undertaking.

WORK IN AMERICA

In America both his efforts to form his own company for the exploitation of his ideas and his early attempts to convince others of their soundness met with failure. However, in 1923, Westinghouse gave him freedom to carry out basic research in fields closely related to the ultimate goal. In the same year Zworykin filed a patent application based on earlier disclosures on a television camera tube, which he named the iconoscope. It was the first television pickup device to incorporate the principle of signal storage, essential to a practical television service.

Only a few months later Zworykin could demonstrate a crude form of an all-electronic television system. The object transmitted was a cross mark. His concurrent work in the fields of photoelectricity, facsimile, and sound motion pictures was to provide, in part, the knowledge needed to pass from the cross mark to a recognizable picture, and from a recognizable picture to one which conveyed both intelligence and entertainment.

The major part of this program, which involved the perfection of the iconoscope and the development of the kinescope, or picture viewing tube, took place in the laboratories of the Radio Corporation of America (RCA), to which he was transferred in 1930 incidental to a redistribution of activities. The enthusiastic support of David Sarnoff, then president of RCA, enabled Zworykin to carry on his work with an enlarged staff and improved facilities. Progress was accelerated by an integrated program which included other technical branches of RCA, adding engineering development and field testing.

The Edison Medal

As a consequence Zworykin and his coworkers were able to demonstrate, in America, high-quality television pictures by purely electronic means before engineers and research men elsewhere had fully awakened to the potentialities of the storage pickup tube first described in Zworykin's patent application of 1923. This technical leadership in the field of television has been retained by America ever since. The more sensitive image orthicon and the Vidicon, which have, at present, largely replaced the iconoscope as television pickup tubes, are, like the iconoscope itself, children of the same research progression.

Although electronic television has provided the central theme for the work of Zworykin and his staff, it has never set boundaries to his interests. Repeatedly, television research has served as a starting point for developments which have led to devices whose utility extends far beyond television. The secondary-emission multiplier, the image tube, and the electron microscope may be cited as examples. At the same time such developments, valuable in themselves, have contributed importantly to the solution of television problems.

Today, Zworykin continues to guide the Electronic Research Laboratory at the David Sarnoff Research Center in Princeton, N. J. As vice-president and technical consultant and chairman of the Planning Committee of the RCA Laboratories Division he contributes to the over-all direction of RCA's research activities. His interest in his brainchild, electronic television, is as keen as ever. Particularly its potentialities for education and scientific research excite his enthusiasm.

HONORS AND AWARDS

Zworykin's contributions to science and engineering have been recognized by numerous honors and awards. Among them, the grant of the Lamme Medal of the AIEE in 1949 stands particularly high in his estimation.

> Vladimir: It is given to but a few in any generation to achieve as you have achieved. I have in mind achievement in terms of your valued contributions, and achievement in terms of recognition by your peers. I am a firm believer that we are all here for a purpose, that we have obligations to use well our talents and our resources. That you have performed well in science is today self-evident. We are here to do you honor as others have done before. It is not enough, however, for any man to rest fully on his direct accomplishments if he is to have spent a full and productive life. The cycle must continue; others through inspiration and leadership must carry on. By your example and by your encouragement you have provided the steppingstones for a succession of younger research workers. It is in this area that I see greater and greater obligations for you in the future. You should find rich rewards in observing the accomplishments of those who, in

> the expression of old, have "sat at your feet." This is a spring which for you need never go dry. This calls for an unofficial title. You have and you are earning it—may it be fully yours—an "Elder Statesman of Electronic Research."

It is with both personal and professional pride, therefore, that I present Dr. Vladimir K. Zworykin, an Elder Statesman of Electronic Research, as the Edison Medalist for 1952.

The Evolution of Television

V. K. ZWORYKIN
FELLOW AIEE

I AM DEEPLY APPRECIATIVE of the honor conferred on me by the AIEE through the presentation of the Edison Medal. It is a privilege indeed to have my work adjudged as following in the great tradition of accomplishment created by Thomas Alva Edison. I regard this honor not merely as a recognition of my work as an individual. More properly, it is a measure of the impact on present-day society of television, the primary objective of many men besides myself.

I must admit that the magnitude of this social impact proved, initially, as much of a surprise to me as to any outsider even though I had been intimately connected with the technical development from the very beginning. It was perhaps a reflection of my training and environment that I saw in television primarily a tool for increasing man's knowledge through an extension of his sense of sight. The observation of the stars from beyond the reach of atmospheric disturbances seemed a natural objective of television. The exploration of vital processes in cells with radiations to which the eye is insensitive presented another valid challenge. Finally, the possibilities of television for acquainting men with the larger world about them appeared unparalleled.

Under the circumstances it must not surprise you that there have been times of discouragement, brought about by the absorption of large segments of the public with inferior program material provided by television. Television, with its initial success, appeared to fall short of its promise of furthering understanding, advancing knowledge, and enriching life.

With the passage of time, however, such worries have proved to be less justified. On the one hand television audiences have become more selective as the novelty has worn off, and have exerted their influence in favor of better programs. On the other hand, the use of television for educational and scientific purposes is being expanded rapidly.

Dr. Zworykin, 42d Edison Medalist, with his award

The impressive experiment in political education in which the networks have co-operated during the political conventions and the election campaign is only one phase of this tendency. Universities and other educational institutions throughout the country are becoming increasingly aware of the potentialities of television as a teaching medium, both on and off the campus. More than that, television can serve as an ideal medium for acquainting the public at large with the methods of education employed in the schools which it supports. In this manner enlightened school board policies can count on the backing of an informed citizenry and create a firm foundation for our democratic system.

The scientific application of television has been furthered particularly through the development of highly compact industrial television equipment, combining simplicity and flexibility with low cost. Television cameras weighing only a few pounds observe manipulations with explosives and radioactive materials from exposed vantage points. Wherever high temperatures, close quarters, and remoteness render observation difficult, the television camera becomes an effective substitute for a human observer. In control applications it allows a single observer to watch several separated events at the same time. Conversely, in visual education the television camera permits the intimate viewing of a single event by great numbers of observers. Camera tubes sensitive to the ultraviolet and infrared reserve a special role to television. Such tubes extend the range for the direct observation of objects and processes beyond the visible spectrum. This is just one factor which has made the television microscope a research tool of great value.

In brief, even now television is contributing to the effectiveness of the processes of democratic government; it is extending the scope of our educational institutions; and it has proved an effective tool for advancing the frontiers of knowledge. These accomplishments and the even greater promise of television are, to me, the best reward for a lifelong effort spent in carrying its development from first beginnings to the present advanced state of the art.

V. K. Zworykin is vice-president, technical consultant, and director of electronic research, RCA Laboratories Division, Radio Corporation of America, Princeton, N. J.

Accurate Computation of 2-Machine Stability

R. D. GOODRICH, JR.
MEMBER AIEE

TWO-MACHINE stability problems can be solved more accurately by utilizing composite general circuit constants.[1] These permit the inclusion of losses, intermediate loads, transformer taps, and so forth, without an excessive amount of labor. The only restriction on their use is that loads must be represented as constant impedances; but this is a conventional assumption for stability studies. In addition this method makes it possible to include the inertia of both machines without approximation.

Representing the relation between machine output power and the relative angle between machines by a sinusoidal function, derived from circle diagram formulas,[2] permits the integration of the second order differential equation for machine swings.[3,4] The result is an equation of relative machine velocity which can be converted to the concise, generalized form:

$$\omega' = \sqrt{R\theta + \cos\theta - C} \qquad (1)$$

In this expression ω' is the generalized relative angular velocity of the two machines, θ the generalized phase angle between machine voltages, R the ratio of the initial or steady-state power to the maximum power transferable, and C a constant of integration which is a measure of the total excess energy, potential plus kinetic, in the system during the swing. The factors relating actual system quantities to the generalized values take into account system losses and machine inertias.

If, for given values of R and C, ω' becomes zero for a value of θ, θ_{x2}, greater than $\theta_e = \sin^{-1} R$, the system is stable. For a given value of R, a minimum value of C, C_B, can be found below which no value of θ_{x2} exists. In other words C_B is a boundary line condition: for larger values of C the system is stable; for smaller values, the system is unstable. The curve of R versus C_B is shown in Figure 1. By plotting computed values of R and C for a particular system on this graph, a quantitative estimate of the degree of stability of the system can be obtained.

Integration of equation 1 would yield an equation of relative angle versus time. As yet no rigorous method for performing this integration has been found, but the operation has been performed arithmetically, using Simpson's Rule, for selected values of R ranging from 0.3 to 4.0, and appropriate values of C. The results are plotted in the form of curves similar to those shown in Figure 2. Here T is a generalized time co-ordinate related to actual time in seconds by a factor dependent on system losses and inertias, and corresponding values of ω' are also plotted.

These curves make it possible to include switching times in the stability analysis, as the relative angle and velocity between machines at a switching discontinuity can be determined. Thus the effect of sequential tripping or time of reclosure can be included without approximation or excessive labor.

The method is particularly well adapted to the determination of stability limits of a system, because changes in system constants can be neglected as the power transferred through the system is changed.

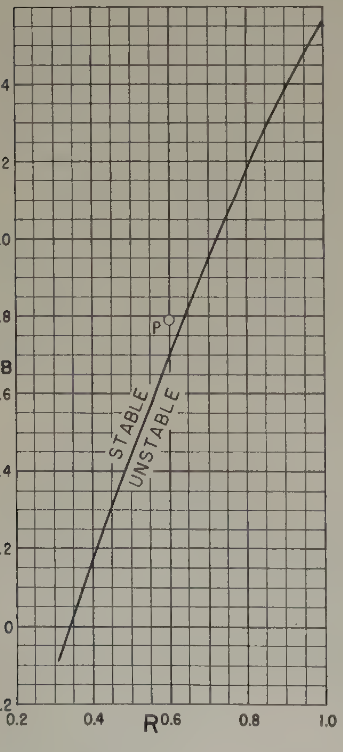
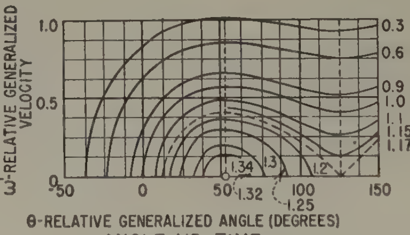
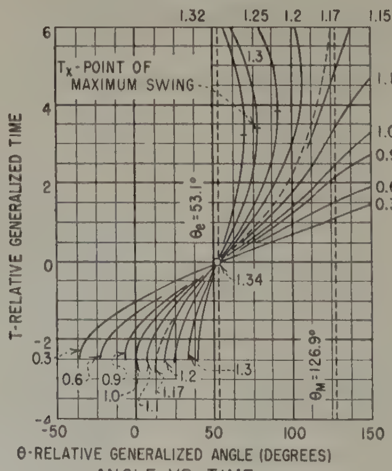


Figure 1. R-C characteristic for determining degree of system stability



ANGLE VS. TIME



ANGLE VS. TIME

Figure 2. Generalized stability curves for R = 0.80

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Analogue Computers for Feedback Control Systems

R. A. BRUNS
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FEEDBACK CONTROL DESIGN is passing into a third stage of development as the systems become more complicated, less subject to linear treatment, and more susceptible to noise problems. Before 1934, empirical methods were usually satisfactory since regulators required relatively little accuracy. Thereafter, with war requirements for accurate positioning devices, it was necessary to design servomechanisms carefully so that linear theory could be applied. But the present tendency in feedback control systems is to include the effects of saturation resulting from large-signal input, the irregularities of amplifying elements, and to utilize relay systems and nonlinear elements to obtain a better solution to the control problem. To study such systems, analogue computers are useful; this article reviews some of these systems.

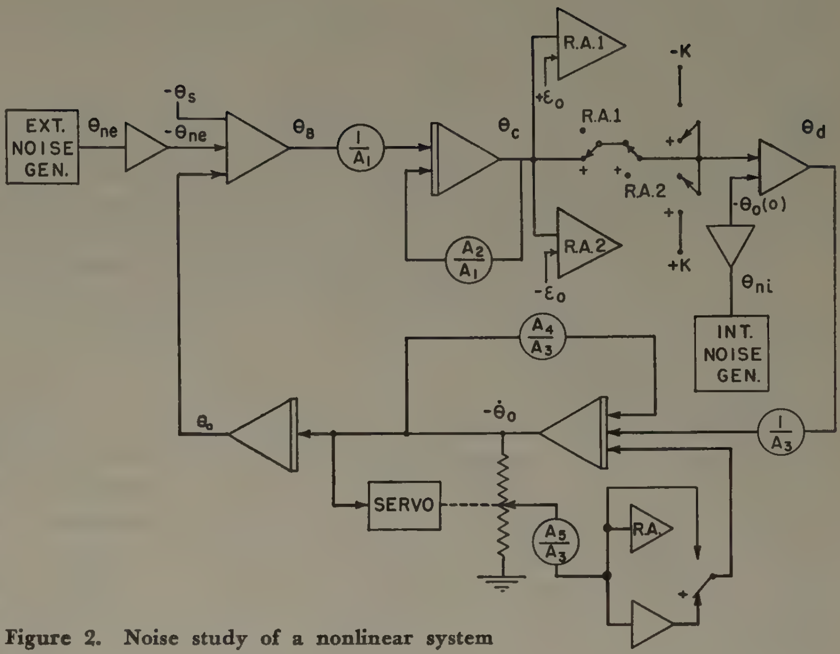

Figure 2. Noise study of a nonlinear system

For example, consider the feedback control system, Figure 1, with saturation, nonlinearity, and noise. Between θ_c and θ_B is a time delay with limiting on the output. A nonlinear differential equation relates θ_d and θ_0: $\theta_d = A_3\ddot{\theta}_0 + A_4\dot{\theta}_0 \pm A_5\dot{\theta}_0^2$. External and internal noises are present, represented by θ_{ne} and θ_{ni} respectively.

Its analogue in Figure 2 contains two noise generators and the necessary components to represent the system. The first time delay is obtained with an integrator and potentiometer in the feedback path. Limiting action is provided by using high-speed relays with two relay amplifiers, designated *R.A.* 1 and *R.A.* 2, with two sets of contacts for each. This simulates the section of the system of Figure 1 between θ_c and θ_B. In the second arrangement, two integrators supply the $\ddot{\theta}_0$ and $\dot{\theta}_0$ terms. The nonlinear term, $\dot{\theta}_0^2$, is obtained with a multiplying servomechanism, another relay amplifier handles the sign reversal. All summers and integrators shown provide signal phase inversion.

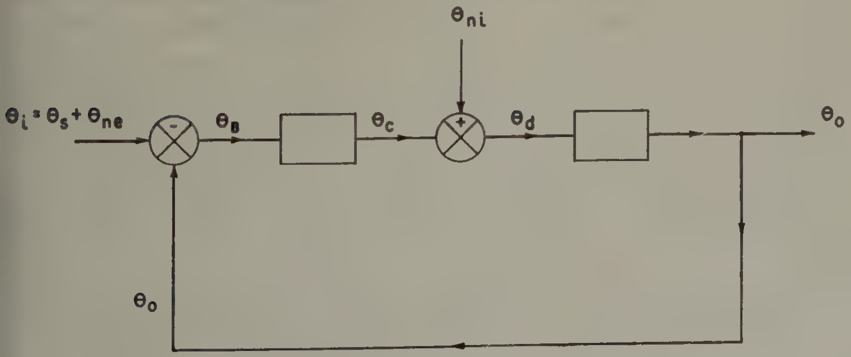

Figure 1. Feedback control system with noise

Once the system is instrumented, typical input signals may be applied and the responses recorded. The more complicated the system, the more accurate must be the computer and recorder equipment for meaningful results, especially if noise studies are to be made. Obviously, if there is computer noise or drift, well designed noise generators lose their significance. For such statistical studies, numerous runs must be made to verify results. This requires special equipment such as automatic sequencers, digital readout devices, and calculating machines.

Therefore, the analogue computer, in particular the electronic type when numerous runs are required, is proving a useful tool in the synthesis of feedback control systems which do not lend themselves readily to straightforward theoretical approaches. Through the use of high-speed relays, multiplying or dividing servomechanisms, and specially designed noise generators, complicated systems may be instrumented. If the mathematical relations are measurable or the components of the actual system reproducible and the computer and associated equipment are sufficiently accurate, helpful data can be obtained for the design of involved feedback control systems.

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Some of the background for this article was received while the author was with the Hughes Aircraft Company, Culver City, Calif., during the summer of 1951.

Power Supply for Nuclear Research Laboratories

C. T. GRAUER
ASSOCIATE MEMBER AIEE

As the nuclear research laboratory is supplied with numerous lethal equipments, adequate safety measures are imperative. Another important consideration for such laboratories is flexibility of the power system as changes are so frequently necessary. Some of the specific requirements of both utility and research power are discussed.

MOST manufacturing or industrial plants design their power systems to meet the needs of a carefully planned process. The design is generally based upon years of experience and embodies standardized equipment, well known and readily available. Once built, changes would be made only when justified by plant expansion, change in product, or other economic reasons.

In contrast, the research laboratory produces basic scientific knowledge and acts as a proving ground for new ideas. Consequently, laboratory power systems and wiring frequently must be altered as the experimental work progresses. In nuclear research work a very flexible power system is needed. It should have a wide range of voltage and current levels for single-phase, 3-phase, and direct currents.

The operation of experimental equipment and of the various types of particle accelerators will impose loads of widely differing characteristics. Such loads may vary from a few kilowatts applied on a random basis, through steady loads at high power factor, to pulsed loads of several megawatts peak power.

Bulk power consumption in a large laboratory can be divided into two broad classes:

1. *Utility Power:* for the shops, offices, chemistry laboratories, and the small experimental areas.
2. *Research Power:* for the large experimental loads and operation of the particle accelerators and their associated equipment.

UTILITY POWER WIRING

IN THIS CLASSIFICATION there is the power used for lighting, heating and ventilating, power-driven tools and machinery, heat treating, pumping, welding, crane operation, alarms and communication equipment, and so forth. The wiring for such loads is of a "permanent" nature, meets all safety codes, and generally conforms to standard practice for a specific occupancy such as space for scientists, office workers, engineers, and skilled craftsmen.

The word permanent, however, must not be taken too seriously, because today's office may become tomorrow's shop. Therefore a flexible wiring system is necessary, for such alterations are expensive, justified only by the importance of a project and its timing. In such an area, a large increase in electric load due to change in occupancy presents the problem of having ample power available in the immediate vicinity.

A primary distribution system, for example a 12-kv radial system, terminating in outdoor transformer yards provides flexibility in that the various transformers can be changed to suit new power demands. However, an inadequate service from the transformer secondary into a building may prove to be a bottleneck for future expansion.

The use of standard wiring materials, plus ample feeder capacity into an area, shortens alteration time. For inside wiring the use of Thinwall conduit, flexible conduit, cables placed in troughs, and so forth, can be adopted where these methods do not conflict with the wiring codes. The power feeder into such areas can be run through rigid conduit somewhat larger than necessary for the immediate load. If the load increases, due to a change in building occupancy, a larger service can replace the original feeder. In some cases it may be necessary to remove feeders having the rubber-covered weatherproof or thermoplastic weatherproof insulations, and replace them with the asbestos or heat-resistant-type insulation for heavier loading on the same size wire.

If the original feeder was a 240-volt line, this can be changed to a 480-volt feeder without replacement since the insulation will be code-rated at 600 volts for wires in the low-voltage class. A few banks of dry step-down transformers located within the building at the load centers will then double the available building power without changing the service wires, which will be carrying the same rated full load current. In some types of buildings which are used for both office space and small laboratory rooms it is economical to install overhead bus ducts along hallways and in locations where they will not disturb the esthetic eye. Where the room occupancy changes frequently, such an installation becomes a very convenient means of increasing or decreasing the service into any room.

If the building contains chemical laboratories whose work involves the handling of radioactive materials, an emergency power supply will be necessary to carry the ventilation load in case of power failure. This is very important! Failure of ventilation for a sufficient length of time can result in a difficult and time-consuming decontamination process. The stand-by power can be

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supplied by small diesel- or gasoline-engine prime movers. The generators may have ratings just large enough to carry the ventilation load plus a few of the most critical experimental circuits.

Here again, circuit flexibility is needed so that the noncritical loads can be quickly isolated. The use of a careful numbering system, plus a few colored labels, simplifies this problem.

UTILITY PLUGS AND RECEPTACLES

With so many voltage and current levels available in the laboratory, a standardized system of plugs and receptacles is a necessity. This will enable laboratory personnel to recognize the voltage, phasing, and current ratings of an outlet merely by looking at the shape of the receptacle. The receptacles in Figure 1 show what can be done with standard units, of which there is a wide variety on the market, all having some outstanding advantage for a specific use. Those shown were selected on the basis that the geometrical arrangement of the pins will prevent the insertion of a plug of one voltage or current rating, into a receptacle of some other voltage or current rating. These nine units will supply three circuit ratings without equipment ground and six ratings with equipment ground.

The ability to ground the metal cases of portable devices is of even greater importance in the research laboratory than in the home because there is such a variety of test equipment and so many voltage levels in use. One frequently finds signal generators, scopes, vacuum-tube voltmeters, amplifiers, and miscellaneous metal chassis-mounted test equipment, all close to an experimenter.

An accidental contact, internally, between an anode circuit component and a metal case not solidly grounded becomes a very real hazard to a researcher. In some types of equipment it is necessary to have the entire instrument floating at a high potential to ground, and this is done safely by mounting the unit on insulators behind plexiglas windows. In general, however, most instrument cases can be grounded. This is recognized as a safety requirement in the California State Electrical Code, which calls for the grounding of all portable appliances.

Since the code does not permit the neutral wire to be used as the equipment grounding conductor, a 3-pin plug and 3-conductor cord will be needed for grounding portable test equipment. In this matter, it is unfortunate that the manufacturers of test instruments have not, to date, adopted the use of 3-conductor cords and 3-pin plugs. The replacement of these cords and plugs for safety purposes becomes an added task and expense for the busy laboratory.

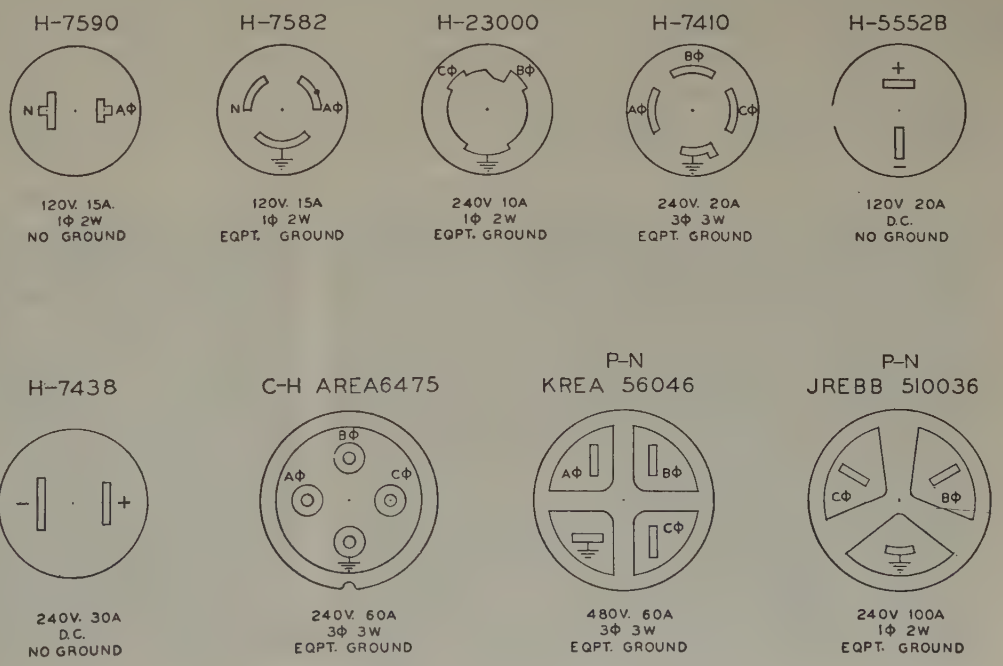

Figure 1. Power receptacles

A quick method of changing an office into an experimental room is to move in a number of standardized test benches, all made uniform as to size and shape, and prewired identically with "plug-in" strip. Experience has shown that the most reliable and flexible types are those into which the standard receptacles can be snapped, and then connected as in typical race-way wiring. Using this method, the units shown in Figure 1 maintain the features of standardization and also simplify the stock problem. A group of receptacles in one strip, protected by a circuit breaker to match the receptacle rating, can then be plugged into the nearest wall outlet. Circuit breakers are preferable to fuses in the laboratory because they discourage tampering.

UTILITY CIRCUITS

In an office building, or one in which there are many small single-phase 120-volt experimental circuits, the conventional 3-phase 4-wire Y system can be used to best advantage because it places such a well-balanced load upon the area supply system. A few 3-phase 3-wire 240-volt loads such as elevators, ventilators, and so forth, can then be supplied by means of small dry transformers, connected Y-delta to transform from the 120/208-volt system to 240 volts for the special 3-phase loads. If then the building occupancy changes so that most of the new loads are 3 phase, 3 wire, 240 volts, the transformer bank feeding the building can have its secondary reconnected for 3-phase 4-wire delta with one leg of the delta center-tapped for a neutral. This will then provide 3 phase, 240 volts, and 1 phase, 240/120 volts, for lights, receptacles, control circuits, and so forth. Thus, it is desirable to install transformers having the 240/120-volt secondary windings.

Where one large transformer bank supplies a group of

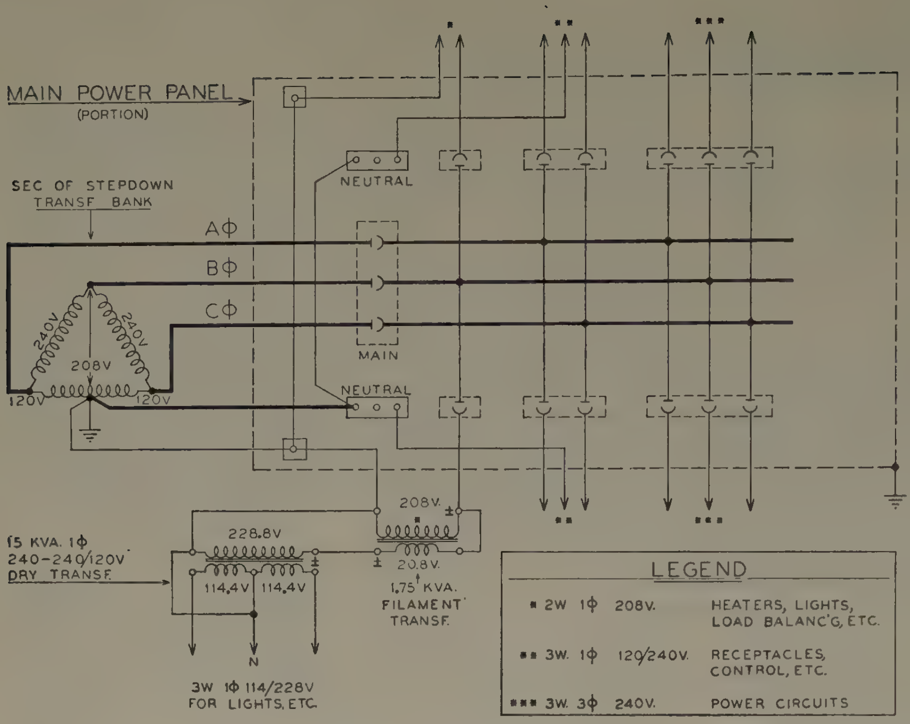

Figure 2. Distribution circuit

buildings, the choice of secondary connection must be based upon the prevalence of 240-volt 3-phase loads as compared to 120-volt 1-phase loads for lighting, and so forth. Using the afore-mentioned 4-wire delta system, a point may be reached where the phase loads become badly unbalanced. A simple, though somewhat awkward, solution for such a situation is shown in Figure 2, using standard filament and dry step-down transformers. Here, the 208 volts from *B* phase to neutral is stepped up to 228.8 volts, using a 1.75-kva filament transformer with a 10 to 1 voltage ratio. This 228.8 volts is then supplied to a standard 240-240/120-volt dry transformer of suitable kilovolt-ampere rating, and stepped down to 228.8/114.4 volts, 3 wire, single phase. This method loads *B* phase and helps restore a balanced load condition on the main transformer bank, but leaves much to be desired from an efficiency viewpoint. In addition to the excitation losses, two transformers are required plus the space and labor of mounting them. A simpler solution would be the use of a 208-240/120-volt transformer, but these are not always available on short time schedules.

Good voltage regulation must be maintained for the experimental areas in which accurate measurements are made. Good regulation is also needed for the various types of radioactivity counters, scalers, and monitoring equipment. This is especially true where these devices are designed and serviced. At present, many of the later types of radioactivity monitoring instruments have built-in voltage regulation so that their operation is satisfactory if the building supply voltage is regulated to within ±1.25 per cent. For this purpose the conventional tap-changing autotransformer regulator, having the standard 5/8-per-cent taps and a 30-second time delay to prevent excessive contact wear, will be satisfactory. But for experimental development work such regulation is totally inadequate and must be supplemented with additional regulators of the resonant-circuit–high-leakage-reactance type or the saturable-reactor type which embodies a rectifier controlled by a voltage-sensitive Wheatstone bridge. Harmonic distortion of several per cent will be noticeable in the output of both types.

Where small amounts of direct current are needed, the portable rectifier is convenient. Such units can supply as much as 1,300-watts direct current from the standard 120-volt 15-ampere single-phase wall outlet. For values of direct current up to 6 kw, a portable 3-phase full-wave rectifier plugged into a 240-volt 20-ampere 3-phase wall outlet can be used. For direct currents up to approximately 18 kw, portable motor-generator sets are used. These can be plugged into the 240-volt 60-ampere 3-phase outlets. All of these wall receptacles are shown in Figure 1. These portable motor-generator sets are completely assembled units equipped with circuit breakers, motor starting contactors, self-contained regulators, meters, overload relays, pilot lights, toggle switches for local or remote operation, and so forth. The regulators can hold the output current constant to within 0.05 per cent if needed. These motor-generator sets also can be equipped with field reversing contactors so that there will be a rapid decay of current in circuits having large inductance, such as experimental magnets. A portable 20-kw motor-generator set of this type is shown in Figure 3. Where it becomes necessary to fully load or overload these machines, they are generally wired in solidly rather than through plugs and cables.

RESEARCH POWER

SEVERAL SERVICE FEEDERS at 12 kv or higher are required for the large experimental loads and for particle accelerator operation. This provides some flexibility so that new units can be constructed without interfering with the operation of existing equipment. With several main services, plus an adequate switching structure, service continuity is assured.

The public utility which serves a large laboratory may well be concerned with the types of load placed upon its system. These vary over a wide range, from ideal to undesirable. In the ideal group a large cyclotron is the best example, requiring about 1,000 kw for an average of 500 hours per month. Of this 1,000 kw, about 850 will be at 80-per-cent leading power factor for operation of a motor-generator set which supplies magnet power, a very steady load.

In the undesirable class there will be the pulsating loads which vary over a wide range in peak power, length of pulse, pulse repetition rate, and duty cycle. The two principal methods of reducing the annoyance of such loads are

1. Scheduling operation for the hours between midnight and 8:00 a.m.

2. Use of large motor-generator sets equipped with flywheels, or use of stored energy in large capacitor banks.

Of the first method, about all that can be said is that it transfers the unhappiness of the utility onto the researcher.

The second method is the more promising. Flywheels have been in use for many years and one finds an interesting example in the case of the cloud chamber generator. Cloud chambers are used in the research laboratory as a means of photographing highly accelerated particles. These particles, traveling at high speeds through a vaporized chamber, are deflected from their line of travel by a magnetic field applied for a few seconds. Such a magnet may require a d-c pulse of 4,000 amperes at 200 volts. This 800-kw load rises to its peak in approximately $2^{1}/_{4}$ seconds at which time the generator field is automatically de-energized. The current then decays to about 200 amperes in the next 10 seconds at which time it is safe to open the main d-c circuit breaker. These pulses are repeated about 30 times per hour.

The cloud chamber generator which furnishes this power is shown in Figure 4. The generator has an intermittent rating of 3,000 amperes at 180 volts, or 540 kw. It is driven by a 150-horsepower 480-volt 3-phase induction motor, squirrel-cage type. Between the generator and the motor there is a 3.8-ton flywheel. A 300-horsepower hydraulic coupling is used between the motor and the flywheel. This permits easy reduced-voltage starting of the motor, which then brings the flywheel-generator combination up to speed, 1,170 rpm, in several minutes. At full idling speed this motor draws 30 kw from the line. At the peak of the 800-kw d-c pulse, the motor draws approximately 330 kw from the line. There is a 13-per-cent reduction in flywheel speed as it gives up some of its stored energy, while the motor decreases its speed approximately 5.5 per cent. A selective control system is provided so that pulse power, time, and repetition rate can be varied. With this equipment, the 60-cycle system sees only 41 per cent of the peak power taken by the cloud chamber magnet.

An example of an accelerator using the stored energy in a large capacitor is the Electron Synchrotron, which accelerates electrons to an energy level of 335 megelectron volts. A constant frequency of 47.7 megacycles at 3.5 kv is maintained across the accelerating gap, while the electrons are held in synchronism by a rapid rise in magnetic field strength to approximately 11.5 kilogauss. This is accomplished by discharging a large capacitor through the magnet winding.

This capacitor and magnet form an inductance-reactance circuit resonant at 32 cycles, at which frequency the capacitor is rated 29,200 kilovars. The peak current and voltage at time of discharge is 3,060 amperes at 19 kv. The discharge lasts 1 full cycle, of 32-cycle frequency, while the pulse repetition rate is 6 per second.

The capacitor is divided into two banks of 1,636 microfarads each in series with the magnet and charged during the pulse interval from a 3-phase full-wave rectifier having a 100-kw 480-volt 60-cycle power supply. Pulsing is accomplished by firing two sets of ignitrons, connected back-to-back, momentarily connecting the two capacitor banks in series and forming a discharge path through the magnet. The simplified circuit is shown in Figure 5.

A pair of diode limiter tubes plus a 60-henry choke, limit the rectifier current to a safe value during the ignitron firing period. With the capacitor banks in series, total capacitance is 818 microfarads, providing stored energy of 148 kilowatt-seconds, derived from the conventional

$$E=1/2CV^2$$

where C is measured in farads, V in volts, E in watt-seconds.

During each pulse the energy dissipated in the inductance-reactance circuit is 12.3 kilowatt-seconds or 394-kw pulse peak power for a pulse length of 1 cycle. Under these pulsing conditions the duty cycle will be 18.75 per cent resulting in averaged power losses of 74 kw in the inductance-reactance circuit, while additional losses in capacitor bleeders, diode limiters, transformers,

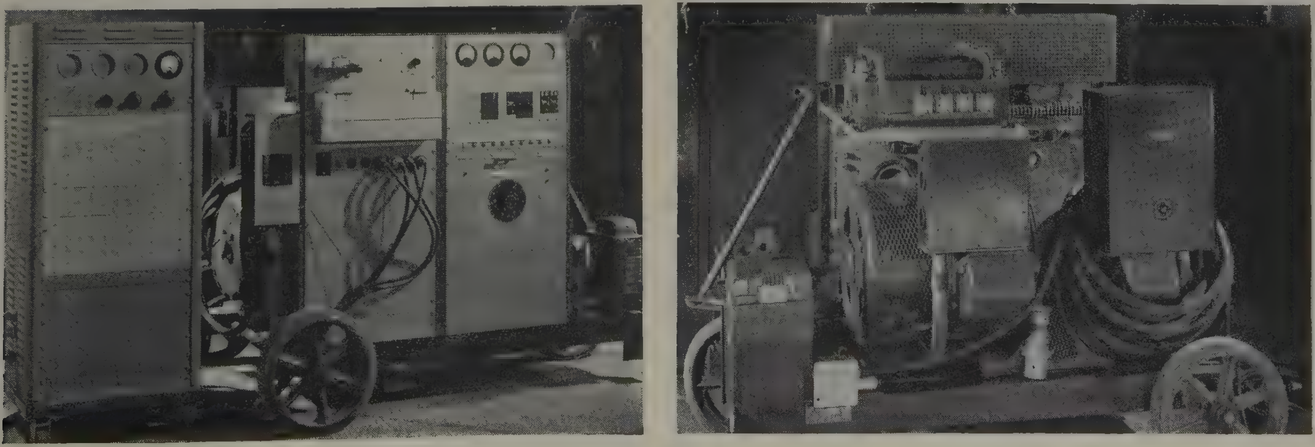

Figure 3. A 20-kw portable motor-generator with regulator: (left) front view; (right) rear view

and induction voltage regulator, impose a total average load of approximately 100 kw on the 60-cycle system, with relatively small variations during pulse and pulse-interval periods.

BEVATRON POWER

The Bevatron, which accelerates protons to approximately 6 billion electron-volts, utilizes the stored energy in large flywheels for the excitation of its magnet. This magnet weighs 10 kilotons, is wound in quadrants and requires 733,000 ampere-turns excitation (per quadrant) for a maximum magnetic field strength of 16 kilogauss. It is pulsed at approximately 100-megawatt peak power, and requires 550,000 cubic feet per minute of air cooling to carry off its heat losses. The blowers are driven by two synchronous motors, each rated 250 horsepower for full-speed drive. For half speed, 40-horsepower motors are ample, since the power input to these blowers varies as the cube of their speed.

Magnet excitation is provided by two 46,000-kva 12-phase 5,500-volt generators, driven by 3,600-horsepower 12-kv wound-rotor motors, each equipped with a 67-ton flywheel. Eight groups of continuously pumped ignitrons rectify the generators' currents, providing peak currents of 8,333 amperes at 18 kv across the magnet. This is made possible by the winding configurations, in which the voltage to ground at any point will not exceed 4,500 volts.

The pulse wave shape is triangular, rising to a crest in 1.85 seconds, decaying in 1.85 seconds during inversion, followed by a pulse interval of 1.4 seconds, the pulse repetition rate being 10 per minute. The magnet will store approximately 83 megawatt-seconds of energy due to its high inductance, again derived from the conventional

$$E=1/2LI^2$$

where L is in henrys and I in amperes.

Each flywheel gives up approximately 40 megawatt-seconds of stored energy during pulse rise time, this energy being returned by inversion from the magnet during current decay and off-time, thus protecting the 60-cycle system from the 100-megawatt peak pulses.

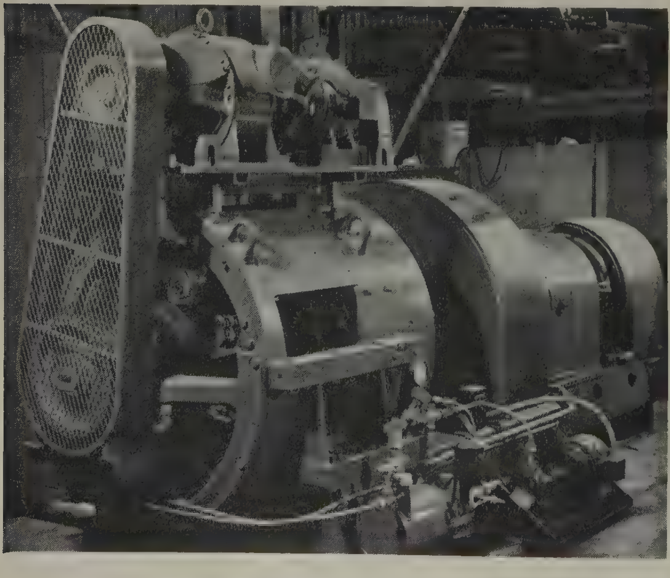

Figure 4. Cloud chamber generator

These motor-generator sets require 6 minutes starting time during which period the average power input is 2,250 kw each. With such large flywheels, the inertia of each machine is more than 1,800,000 foot-pounds squared. Dynamic braking is used to stop them. The grid resistors in the wound-rotor circuit which are used for starting are also used to absorb the power generated in the rotor during the braking period. A totalizing demand meter installation is used as a guide in the operation of these machines to soften the financial shock of the billing demand charges.

SELECTIVE D-C SOURCES

In the research power class, one can include various motor-generator sets in sizes from 30 to 1,250 kw which are used for supplying direct current to magnetic research areas. These machines have no flywheels because their loads are constant, but an assortment of voltage and current levels will be needed to cover the range of experimental design work. Here again, flexibility is essential so that the generators may be easily and quickly switched from one test area to another. This switching is expedited by the use of d-c terminal boards, each containing the output terminals, controls, overload relays, and metering of their respective generators. Links connect a generator to cables serving a test area. Bus-bar jumpers, cut to size and ready for use, can connect any machine to any set of load cables. For remote control, starting, and so forth, a standardized control panel is mounted in each of these test areas. These panels are connected to the main generator room with multiconductor control cables, terminating on a cross-connect board, arranged so that any remote control station can be plugged into any motor-generator control circuit.

Each remote magnet or other load device has its own overload relay set to protect it against overload. Each generator has its own relay which is set to a reasonable overload value. In this manner both the machine and its load, large or small, are protected adequately, consequently the switching of loads and/or machines requires but a few moments. In large magnets the current decays so slowly that caution must be used when opening the connecting links. Circuit breakers or switches cannot be used and the load circuit is de-energized by removing the generator field excitation, thus permitting the load current to die out.

ACCELERATOR AUXILIARIES

Of smaller load but equal importance in the operation of particle accelerators, are the various auxiliary devices such as vacuum pumps, radio-frequency supply, ion sources, injectors, deflectors, and so forth, with their associated control, timing, and metering equipment, for the accelerators cannot operate without them. In this class the larger components of load are the vacuum pumping system and the radio-frequency supply which will be described very briefly.

Particle acceleration occurs in tanks, tubes, or chambers

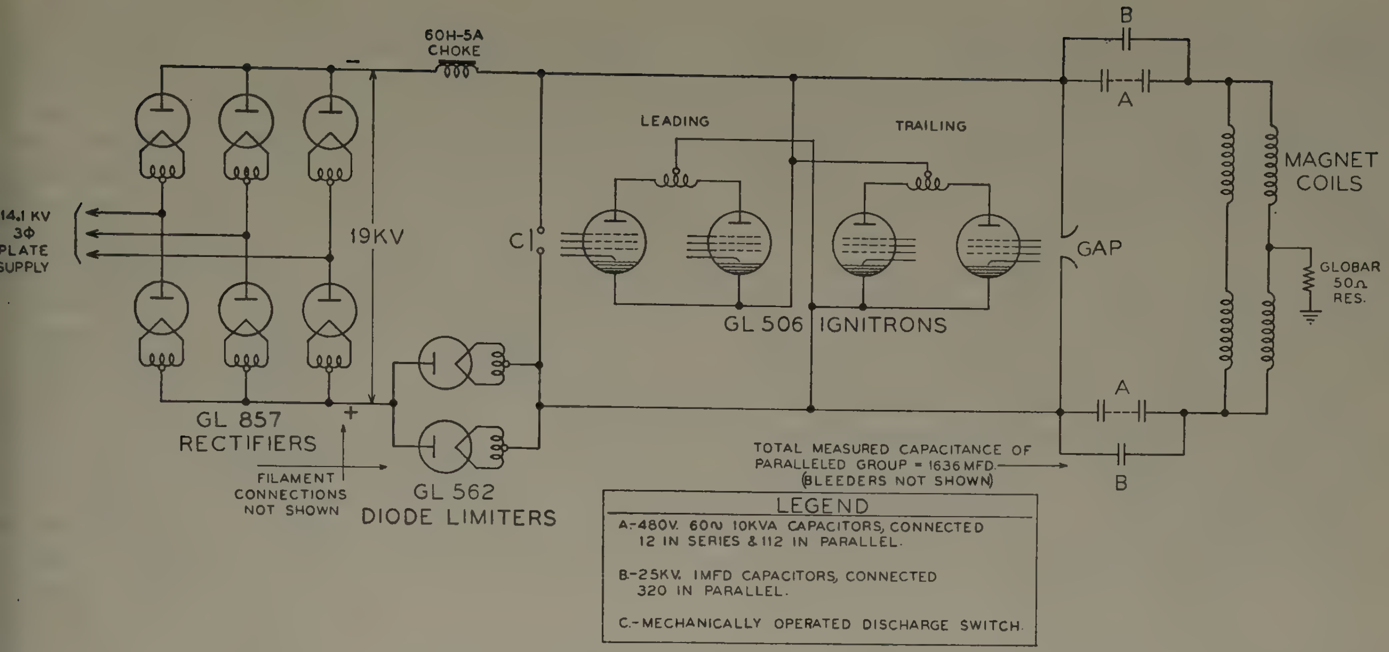
60H-5A CHOKE
−
+
14.1 KV 3Φ PLATE SUPPLY
19KV
C
LEADING
TRAILING
B
A
MAGNET COILS
GAP
GLOBAR 50Ω RES.
GL 506 IGNITRONS
GL 857 RECTIFIERS
FILAMENT CONNECTIONS NOT SHOWN
GL 562 DIODE LIMITERS
TOTAL MEASURED CAPACITANCE OF PARALLELED GROUP = 1636 MFD. (BLEEDERS NOT SHOWN)
LEGEND
A-480V. 60∿ 10KVA CAPACITORS, CONNECTED 12 IN SERIES & 112 IN PARALLEL.
B-25KV. 1MFD CAPACITORS, CONNECTED 320 IN PARALLEL.
C.-MECHANICALLY OPERATED DISCHARGE SWITCH.

Figure 5. Synchrotron basic high-voltage circuit

under high vacuum. These vacua are produced by combinations of oil diffusion pumps and rotary mechanical pumps. Diffusion pumps range in sizes up to 32-inch inside diameter and can draw a vacuum in three stages to 10^{-6} millimeters of mercury, 10^{-3} microns.

They operate on the principle of molecular diffusion of a gas into a vapor which in this case is oil vapor emerging in several pressure stages inside the pump, directed downwards and drawing air molecules from the intake manifold connected to the top of the pump. The manifold is connected to the acceleration chamber or tank of the accelerator. Oil boilers at the base of these pumps use heating elements rated from 6 to 9 kw at 240 or 480 volts, 1 phase. Oil vapor is condensed by means of water-cooling coils around the outside of the diffusion pump, and returns to the boiler tank to complete its cycle. The main pump exhausts into a smaller unit of similar construction called a booster pump. The combination will only work into a fore pressure of about 1 millimeter of mercury, consequently a forepump must be used between the diffusion pumps and atmospheric pressure. For this purpose, a rotary oil-sealed mechanical pump, such as Kinney or the Beach Russ, is associated with each diffusion pump and its booster.

The Bevatron, whose magnet is wound in quadrants, will have six of the 32-inch diffusion pumps, plus their 8-inch boosters, grouped in the vacuum chamber gap between each quadrant. These are rated 10.5 kw, 480 volts, 1 phase each, including the booster, and will be connected into two 3-phase groups, making a 63-kw load at each quadrant gap or a total of 252 kw for the 24 pumps. Fore or primary pumping will be provided by connecting these units with 8-inch pickup lines terminating in a 10-inch suction line run to the mechanical pump room containing eight of the 310-cubic-foot-per-minute size and six of the 105-cubic-foot-per-minute size Kinney pumps. For roughing and finishing purposes there will be an additional 16-inch suction line running directly into a tangent tank.

Of these, the larger units have 15-horsepower motors, while the smaller units are driven by 5-horsepower motors. Allowing 1 kw per horsepower of motor output, this total pumping load will be 402 kw at 480 volts, 3 phase. The eight larger size Kinney pumps will be used for reducing tank pressure, roughing, to approximately 200 microns, after which the 24 diffusion pumps will be used with these eight mechanical pumps to hold a tank vacuum of 10^{-2} microns.

As mentioned previously, the radio-frequency supply equipment places a moderate load on the 60-cycle system. The high-voltage rectifier for the radio-frequency equipment of the linear accelerator is rated 15 amperes at 20,000 volts, or 300 kw. This rectifier charges an 18-microfarad capacitor through a 33-henry choke. When operating at 18 kv, the capacitor's stored energy will be

Figure 6. Main transformer yard

2.92 kilowatt-seconds and when pulsed for a period of 600 microseconds, the pulse peak power will be 4,870 kw. This is the plate power for 9 oscillators arranged along the length of the 40-foot linear accelerator tank. The oscillators are tuned to generate a frequency of 203 megacycles and deliver their output to the series of drift tubes inside the tank.

CONCLUSION

THE MODERN RESEARCH LABORATORY contains so many lethal devices that a persistent safety campaign must be carried on at all times. Highly trained personnel, absorbed in creative work, tend to become unconcerned about the hazards surrounding them, consequently circuits and equipment must be carefully planned so that accidents will be avoided.

High-voltage equipment is screened, gates and doors kept locked, and interlocks are wired into control circuits so that voltage will be removed if doors are inadvertently opened. All outdoor transformer banks, fused cutouts. and so forth, are connected with lead cable-wiped joints instead of the conventional open wiring. Figure 6 shows a main transformer yard, in which everything that is energized is surrounded by steel plates, steel caging, or lead sheath, and solidly grounded.

Cages containing high-voltage equipment are equipped with numerous grounding hooks placed just inside the door where the maintenance man can reach them and hook them onto each point of danger. Equipment which emits rays having high penetrating power, such as the gamma and the X rays, must be shielded with lead or concrete.

Magnetic materials must not be placed near magnets where the application of the field might slam the material against another object or person. Wiring devices subject to radioactive contamination must be expendible, for example, buried in concrete and dumped into the ocean. Sensitive instruments must be shielded against powerful stray fields and protected from corrosive fumes and acids. Water-cooled high-voltage equipment must use very-low-conductivity water, plus removable electrolysis anodes to prevent the disintegration of the plumbing system. These are some of the items which must be considered when planning circuits and designing the electric power supply for the nuclear research laboratory.

Communications for Civil Defense

C. A. ARMSTRONG
MEMBER AIEE

CIVIL DEFENSE REQUIRES communications for two principal reasons. First, to give the people advance warning of impending attacks. The high speeds of modern aircraft require that the communications for alerting must be rapid and reliable. Second, communications are needed by Civil Defense in fulfilling its responsibilities connected with fire fighting, rescue, medical needs, debris clearance, emergency repair of vital facilities, monitoring for specific hazards, and so forth. Communications are needed within cities, between cities in the same state, and on a nation-wide basis. In a real sense communications are the nerves of the Civil Defense effort.

ENGINEERING REQUIREMENTS

THE ENGINEERING OF COMMUNICATIONS for Civil Defense must be based on the following factors:

1. Coverage: ability to interconnect all points between which communications are required and be readily expandable.

2. Expense: a minimum consistent with other requirements.

3. Reliability: dependability under disaster conditions.

4. Security: nonsusceptibility to interception or unauthorized transmissions.

5. Simplicity: easily operated by volunteers.

ATTACK WARNING

Aircraft Detection. Before attack warnings are disseminated, hostile aircraft must be detected and identified. This is the responsibility of the Air Defense Command of the United States Air Force together with Civil Defense volunteers who man ground observer posts and filter centers. To begin with, there is a ground observer located at observation posts spaced about 8 miles apart. In general, regular telephone lines are used in transmitting the observer's reports to a filter center. The telephone traffic routing instructions are such that these calls are completed, not only to the correct filter center, but also to the correct position around a plotting table where the call will be answered by a volunteer who is responsible for plotting reports from the particular observation post which is calling.

By means of direct private-line telephone circuits, the filter center relays "filtered" track information to the

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appropriate radar station. Here this information is again plotted, together with reports from adjacent filter centers. At the same time, strategically located radar sets are scanning the skies and sending appropriate information, again by means of private-line telephone circuits, to the radar station. On the basis of information received from both these sources, fighter intercepter aircraft are called into action.

By means of a direct private-line telephone circuit, the situation both with regard to hostile aircraft and countermeasures taken, is continually reported by all radar stations within an air division to the air division headquarters which is known as an Air Defense Control Center (ADCC). Here the commanding general, or his deputy, is responsible for determining when and what type of alerts shall be disseminated throughout the air division by means of the Civil Defense attack warning system.

Attack Warning System. Alerts are disseminated from an ADCC to civil key-point warning stations by means of a special 4-wire private-line telephone circuit. A typical circuit would be 500 to 1,000 miles long and would connect an ADCC to about 25 key-point cities. To send an alert, the controller at the ADCC operates a key which causes a bell to ring instantaneously and simultaneously in all of the key-point warning stations connected to this network.

The means of providing Civil Defense with the needed communication facilities are presented in terms of attack warning and disaster control. These are evaluated on a basis of coverage, expense, reliability, security, and simplicity.

He then announces the alert and this announcement is heard over a loudspeaker simultaneously at all the key points. The controller then calls the roll of key points and each acknowledges using a push-to-talk handset. This circuit utilizes only 1-way signaling and is so arranged that only the ADCC can be heard by the key points, that is, conversation between key points is not possible. The ADCC can hear all the key points and utilizes a voice recorder to obtain a record of the acceptance of responsibility by the key-point operator for the further dissemination of alerts. In succeeding steps of disseminating alerts, the number of people dependent on the warned point becomes smaller, the number of points becomes much larger, and the cost of providing for acknowledgments increases very rapidly. Therefore, the acknowledgment feature usually cannot be justified in the lower steps of the warning chain.

To meet the requirements of alerting a large number of points quickly, simultaneously, and at a minimum cost, the telephone industry has developed the "Bell and Lights" Civil Air Raid Warning System. A Bell and Lights indicator, installed at each location that is to receive the alerts, is arranged so that a different code ring and a different light signal is received for each degree of alert. These indicator sets are all controlled by a special dial located at the control point from which alerts are sent, normally a key point. Any number of warning points may be connected to a given Bell and Lights network and alternate control points may be provided. This system can be arranged to control the operating of public warning devices such as sirens, horns, whistles, and so forth. With public Siren Control connected to a Bell and Lights network, the system will sound the public sirens on the Red alert—and on the White following a Red alert—simultaneously with the transmittal of the alert to Bell and Lights stations. Confidential alerts (Yellow and/or Blue) will not sound the sirens. The circuit is fully automatic and includes a memory feature so that it will sound the sirens on the White alert if the preceding alert was a Red alert, but will not sound sirens if the preceding alert was a confidential alert.

The Bell and Lights system employs dial pulse signals between the control point and each central office. Between each warning station and its serving central office, the principles of 4-party selective ringing are employed. The station indicators utilize a high-impedance ringer and cold-cathode neon lamps. The principal circuits are under continual automatic test so that trouble conditions will immediately register a "major" alarm in the telephone central office but will not cause the transmission of a false alert. Neither the control point nor the warning stations requires local power.

With both the ADCC-to-key-point circuit and the key-point-to-public "Bell and Lights" system, the transmission of alerts is practically instantaneous. With this combination, the only time delay between the decision at the ADCC to transmit a Red alert and the sounding of sirens in cities throughout the air division, some of the cities being hundreds of miles away from the ADCC, is the time required for two simple operations, (1) the voice announcement of the alert at the ADCC and (2) the operation of the dial by the key-point operator. If it were necessary to alert the entire country within 2 minutes, this could be done if all locations were provided with these arrangements. However, the costs cannot be justified to provide facilities so that the whole country including every town and hamlet can be alerted within this interval. To alert those points, not in critical target areas and where the expense of a private-line system cannot be justified, "chain" telephone calling is the most practicable method.

DISASTER CONTROL

After an attack, communications are required, first, to forward casualty and damage reports so that authorities can obtain an over-all appraisal of the situation. Second, communications are required to dispatch and to direct forces who will combat the spread of fires, rescue trapped people, control traffic, and so forth.

Main Control Center. Within a given city, centralized over-all direction to control and combat the disaster situation is the function of the main control center. An alternate main control center, located a considerable distance from the main control center, serves in the event of the destruction of the latter. Main control centers are selected in secure locations, such as the basement of a steel frame or reinforced concrete building, and need secure and reliable communications with other Civil Defense forces. Within the control center there are two principal rooms which are important from a communications standpoint, an operations room and a message room.

In the operations room a telephone is provided for the Civil Defense Director and for the head of each of the services such as police, fire, public works, transportation, and so forth. In addition to his regular local telephone, the Director should also have a toll terminal line. This will give him direct access to the long-distance switchboard and will serve both to speed service for intercity and interstate communications and to add an element of insurance of the continuity of communications.

A message room is normally equipped with two groups of telephones, one for incoming calls and the other for the dispatching of outgoing messages. The telephones for incoming calls should be in a consecutive number series and appear in a "line hunting group" at the telephone office. The first call will then go to the first line, the next call will automatically switch to the second line if the first is busy, or to the third if both the first and second lines are busy, and so on to the end. The telephones in the message room are manned by volunteer telephonists who, in the case of incoming calls, record each message on a multicopy form. The message room in the larger cities may also include a TWX machine for printed communication with state headquarters and the higher echelons of Civil Defense.

To insure the continuity of communications with the main control center, the telephone service should be capable of being operated from at least two central offices which are separated from each other by several miles. Under these conditions a single bomb probably would not knock out both telephone offices and would not, therefore, sever the communications of the main control center. Any bombing that did knock out both these offices would probably also knock out the control center itself.

The control center will usually be connected to the telephone offices by means of completely underground cable routes. Underground cables are little affected by air-burst A-bombing. These cables are already in their own "bombproof shelters." Whereas high-explosive bombs may sever any underground cable which they hit, this type of damage is of a localized nature and so, if adequate alternate routes are planned beforehand, the severing of one route will not cut all communications paths with the control center. In the suburban areas, away from the likely targets, the preference for underground rather than aerial cable is of less importance.

Zone Control Center. Subordinate to the main control center and depending on the size of the city, there may be several zone control centers. Each zone control center serves its own zone, generally about 10 square miles in area and including 100,000 to 200,000 population. Some cities have equipped all zone control centers on a full-time stand-by basis but, because this is somewhat expensive, many cities prefer simply to designate a number of suitable locations and facilities which have normal peacetime functions but which can serve in an emergency as a zone control center. The selection is based on the availability of existing communications as well as the desirability of obtaining a secure well-protected location. A school or department store basement or a protected location in a hotel are examples of such locations. A compromise plan would include a few fully equipped zone control centers, which are used for no other purpose and which are employed for drills and training, together with a number of other designated zone control centers which are in locations having other normal peacetime functions.

Similar to a main control center but smaller, the zone control center also has an operations room and a message room. While it is desirable to have the incoming message room phones connected in a "line hunting group," this is not essential from a communications standpoint; any establishment which has the required number of telephones may serve as a zone control center.

To understand the problem of reliability of communications for a zone control center and the extent of communications insurance needed, let us refer to a typical city as illustrated in Figure 1. The location and number of telephone central office buildings as shown are identical with an actual city of the size indicated. (In New York City there are 60 separate telephone central office buildings which are similarly dispersed.) Assume that an A-bomb explodes causing an area of destruction represented by the circle. In most of the locations, the circle can be placed where it will cover at least one zone control center and a telephone central office. However, there are certain places where the circle can be placed to indicate the loss of a control center but not its associated central office, and conversely. In any event, there will always be an adjacent zone control center which is served from a working telephone central office and which can function as an alternate for a zone control center which has

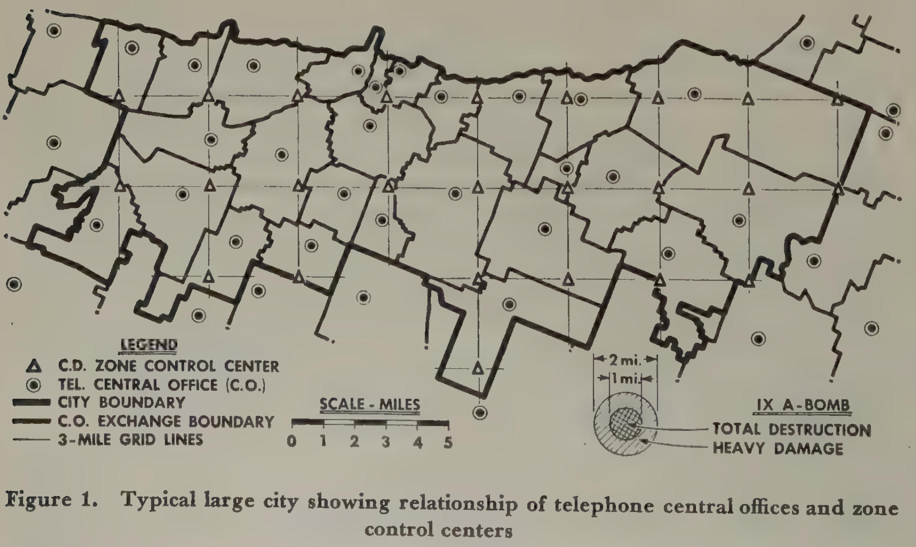

Figure 1. Typical large city showing relationship of telephone central offices and zone control centers

been destroyed or has lost its telephone service. Therefore, it is generally not necessary to resort to any special measures to insure the continuity of communications to a zone control center.

Miscellaneous Communications Points. In addition to the control centers, which are uniquely for Civil Defense, there are many miscellaneous fixed locations to which Civil Defense will require a smaller number of communications channels. Such locations are report centers, the Police and Fire Departments, most of the city departments, hospitals, public utilities, radiobroadcasting stations, rendezvous areas, triangulation observation posts, and so forth. Generally the existing telephone facilities to these places will provide adequate communications. Where there are interruptions to the regular telephone service at any point, use may be made of mobile radiotelephone service.

Communications to any of these miscellaneous points may also be supplemented by means of walkie-talkies or field wire and telephones. Telephone service provided by means of field wire can be established within a reasonably short time interval either by a man on foot or by unreeling the wire directly from a moving vehicle. The hand-carried 2-way radio units are particularly useful where the points requiring communications are not fixed; they are somewhat less suitable for prolonged use between fixed points because of their battery-life limitations.

Pool of Existing Mobile Radio. In addition to the telephone company mobile radiotelephones, there are a large number of other existing 2-way mobile radio systems in everyday use. The Police Department, the Fire Department, and the taxicab 2-way mobile radio systems, are outstanding examples. In addition, there are ambulances, transit companies, the press, various industrial and other mobile radio users. Further, there are a large number of amateurs whose help has always been valuable in emergencies.

Obviously the Fire and Police radio systems will be utilized for the Fire and Police functions of Civil Defense. Rather than assign the other existing mobile radio systems individually to specific uses (such as to assign the taxicab radio specifically to the warden service), generally it is preferable to assign to a pool all of the existing mobile radio systems which might appropriately be used by Civil Defense. Then in a disaster, units from this pool will be assigned to those locations where supplemental communications are needed. In this way, maximum use is made of the available mobile equipment.

Transfer Relays. Transfer relays may be installed in a cable vault or manhole and connected to the telephone lines serving a Civil Defense control center, the Fire and Police Departments, and other essential locations. Then in the event of the destruction of the telephone office which normally serves these lines, the relays may be operated by remote control to transfer the lines to an alternate central office which is located in another building a considerable distance from the regular central office. This application of transfer relays is illustrated in Figure 2. For cities which have only one telephone central office building, what is shown as Office *A* could be a PBX, one which is normally used for other purposes but which can be utilized for emergency operations. It will be observed that this transfer relay arrangement affords service protection by means of diversity and in this respect is approximately equivalent to the permanent provision of lines from the essential location both to Office *A* and also to Office *B*. However, it will be noted that the cable facilities between Offices *A* and *B* are normally used as interoffice trunks and would be used exclusively by the essential subscriber only in an emergency.

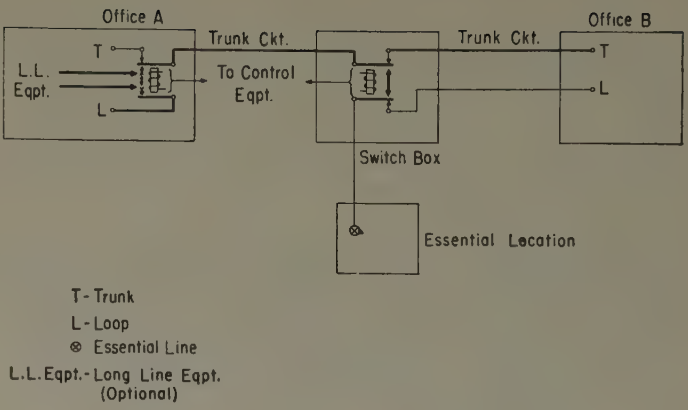

Figure 2. Diversity protection obtained by means of transfer relay. Emergency operation of relay by remote control transfers service from Office B to Office A

Transfer relays may also be employed to permit the immediate restoration of toll service to an alternate toll office or to emergency terminations in the event of the destruction of a toll office. Transfer relays may also be installed to facilitate the immediate restoration of service on various types of private-line circuits. Restoration plans which utilize transfer relays, in contrast to splicing operations, do not have to contend with the removal of debris, getting splicers on the job, and other time-consuming operations.

REVIEW OF REQUIREMENTS

Having outlined the means of providing Civil Defense with the communications which it needs, it is appropriate to examine whether the proposed arrangements meet the basic requirements as set forth at the outset.

1. Coverage. The regular telephone system inherently contains a great deal of coverage in that some service exists in almost every building. There is complete flexibility in that any telephone (or unit of the mobile telephone service) can be connected to any other telephone. For important locations advance arrangements may be made that will permit quick expansion in the number of lines. Telephone supply warehouses, dispersed throughout the United States, carry substantial stocks of telephone material and equipment. These stocks, which are normally provided for growth, now at the phenomenal rate of about 2,000,000 telephones per year, can be used to establish or restore service in an emergency.

2. Expense. As the proposed arrangements would utilize, to the maximum extent practicable, existing facilities which have normal peacetime uses and would be paid for generally by the normal user, both the over-all cost and the cost to Civil Defense will be kept to a minimum. The cost of the transfer relay arrangements as outlined in the foregoing, is generally less than the cost of other arrangements or facilities which would provide comparable diversity for protecting the continuity of service.

3. *Reliability.* Basically, facilities which are in normal day-to-day use are more dependable under emergency conditions than are facilities which are provided for use only during an emergency. The arrangements already outlined are based on this principle. Since communications are of paramount importance to Civil Defense, it is appropriate to examine carefully the factors which determine the reliability of these facilities under disaster conditions.

An outstanding factor which contributes to the reliability of the regular telephone system for disaster communications is the great quantity and diversity of telephone plant. The toll circuits connecting any two widely separated cities are normally divided among several different routes. This is to prevent any single incident, such as a bulldozer accidently cutting a cable, from having any serious effect on the handling of normal day-to-day traffic. Furthermore, toll calls can be completed over alternate routes if their normal routing is not available for use.

Not only is there diversity of routing available, but there is a diversity of the type of facilities used. There are ordinary cables, open-wire lines, coaxial cables, and microwave radio relay systems. Some toll circuit cross sections are very heavy. For example, in the New York–Philadelphia cross section there are about 5,000 circuits which are divided among several different routes and different types of facilities. The Cleveland-Chicago cross section includes over 3,000 circuits which are likewise diversified with respect to route and type of facility.

There are many other important factors which have been provided to insure continuity of telephone communications. For example, the toll cables are under gas pressure and are equipped with alarms at regular intervals so that any troubles which cause a break in the cable sheath thus will register an alarm in the nearest test room.

Another example of emergency protective arrangements is the automatic line-switching circuit associated with the coaxial carrier system; in the event that any trouble on one line causes as much as a 3-decibel change in the received level of a pilot channel, the line-switching circuit will automatically transfer service to a spare line. Similar arrangements are used on the radio relay system to transfer service to a protection channel in case of failure of the regular channel.

Another important factor in the reliability of telephone service is that the local station equipment—the telephones themselves—do not require any local power. The power for their operation comes from the telephone central offices. These are equipped with storage batteries which are of sufficient capacity to carry the load for a reasonable period of time.

In addition to the foregoing, there are stand-by diesel- or gasoline-engine-driven generators which can charge the batteries in the event of an emergency requiring their use. In the smaller offices which do not justify a permanently installed stand-by generator, there are portable generators which can be used as required.

A further important factor behind the reliability of telephone service is the support organization, with standardized methods and materials, that is in existence. There are nearly 700,000 trained people who normally, in their day-to-day business, are operating and maintaining the telephone facilities of the country. These people are organized into a number of individual companies, each one of which is a complete operating unit within itself. Often in past emergencies—earthquakes, floods, hurricanes, and so forth—it has been demonstrated how these trained people can be loaned from different places to a hard-hit area and how they can all work together successfully as a team.

4. *Security.* It is important that the privacy of communications be maintained and that panic-creating information not become available to the general public. A direct private-line circuit provides the highest degree of security for communications between two points. For attack warning, security has a special significance with respect to the provision of false alerts. It is for this reason that the private-line arrangements which have been outlined in the foregoing are needed. The proposed arrangements for post-disaster communications afford the best security that could be provided without multiplying the cost manyfold.

5. *Simplicity.* As Civil Defense communications must be used largely by volunteer workers it is important that their operation be simple. Most people are familiar with the use of regular telephone service in their community. The mobile radio systems will be operated by those who normally operate these systems and are thoroughly familiar with their operation.

CONCLUSION

CIVIL DEFENSE CAN BEST BE MADE EFFECTIVE if it is organized and operated on the principle that existing organizations and existing facilities be used. Therefore, the Police Department, the Fire Department, the Department of Public Works, the Health Department, and hospitals are all assigned the task of training themselves and any auxiliaries they may need for their emergency role in Civil Defense. Similarly it is appropriate that public utilities, such as power and telephone companies, be brought into Civil Defense training and assigned responsibilities for enlarging or adjusting their normal functions to meet an emergency situation.

Civil Defense must be accomplished by reliance on those who are doing, on an everyday basis—in local, state, and federal government, and in industry—work that is similar or comparable to that required in a Civil Defense emergency. The most efficient and reliable procedure is, therefore, to make maximum use of all existing communications agencies together with their trained personnel. These are adequate and reliable.

135-Kv 3,500,000-Kva Low-Oil Circuit Breaker Tests

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A HIGH-VOLTAGE CIRCUIT BREAKER of the low-oil-content type, shown in Figure 1, was field tested in December 1951 to obtain performance characteristics on this unfamiliar design. The equipment tested was manufactured in Switzerland and is rated at 135 kv, 5 cycles, 600 amperes, and 3,000,000 kva on the European symmetrical current rating basis. Test facilities and personnel were furnished by the Bonneville Power Administration. In addition to the usual equipment there was provided a special high-accuracy cam switch designed to control accurately the relative points on the 60-cycle voltage wave at which the fault was applied and the test circuit breaker contacts parted.

Line-dropping tests were made to check the performance of the circuit breaker when switching low capacitive currents. Seven series of tests were made with lines varying from 10 to 246 miles in length with 10 shots at each series. These tests show a maximum of restrikes when dropping a line of 82 miles with a charging current of 22 amperes at 108 kv. The highest but also the most infrequent overvoltages produced by the restrikes were in the order of 2.5 to 3 times normal crest values. Modifications were made to the oil pump and the test on the 82-mile line repeated. These results indicated further modifications of this type of circuit breaker can be expected to improve line-dropping performance.

Seven single-phase line-to-ground faults were made in the range from 760 to 19,000 rms amperes, at the normal operating bus voltage of 108 kv, during the night of December 5–6, 1951. To impose the maximum possible physical duty on the test circuit breaker, the synchronous cam sequence timer was used to control the relative point of fault application and the point of the test circuit breaker contact parting with respect to any given point on the 60-cycle voltage wave. This procedure was followed to produce the maximum possible arc energy, gas pressures, and physical stress within the test circuit breaker.

The circuit breaker interrupted faults without incident in the first six tests. In the sixth test the total rms current was 18,800 amperes, which was 25 per cent higher than rated interrupting current. After several trial adjustments of the cam switch, final interruption following a major current loop, accompanied by an offset slightly above the desired 50 per cent asymmetry, was reached on Test SF-7. The crest value of the final current loop on this test was 22,100 amperes, and the interrupting element failed on this test, though the American Standards Association method of computation actually indicated less total kilovolt-amperes interrupted than in the case of SF-6.

Although the interrupter failed on Test SF-7, this interrupter functioned to provide a normal and complete fault interruption within the rated interrupting time. The porcelain did not disintegrate explosively and the fractured parts fell within an approximate 10-foot radius of the circuit breaker. The fractured upper porcelain caused no damage to the adjacent poles or to the field test equipment. The contact wear was within reasonable limits.

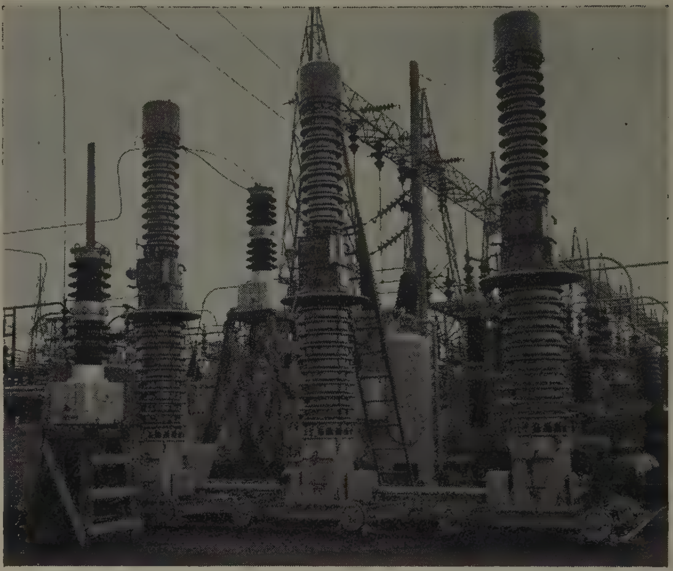

Figure 1. The 135-kv 3,500,000-kva low-oil-content circuit breaker in test position

The following conclusions were made:

1. In regard to line-dropping capability, the authors feel that the circuit breaker performance was satisfactory on 90 per cent of the tests. On 3 tests, or 4 per cent, the line overvoltages exceeded 3 times normal crest value.
2. In regard to interrupting capability, a direct comparison between the computed test results and the equipment rating is rendered rather obscure due to the fact that the tests were conducted at 108 kv, which is considerably below the equipment rating of 135 kv. On the basis of a nominal interrupting rating of 3,500,000 kva, failure on Test SF-7 occurred just under this value. But on the basis of the equivalent interrupting current rating of 17,550 amperes, total asymmetrical, the circuit breaker did not fail until values much above this were reached.
3. This test program proved to be one of the most outstanding in the authors' experience in illustrating the urgent need for early adoption of a revised standard test code by the industry wherein the computed test results will faithfully reflect the actual physical duty imposed on the equipment.

Digest of paper 52-242, "Field Tests on 135-Kv 3.5-Million Kva Low-Oil-Content Circuit Breaker," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Pacific General Meeting, Phoenix, Ariz., August 19–22, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

Lloyd Morgan and **Paul Wildi** are with the Pacific Oerlikon Company, Tacoma, Wash.; **W. H. Clagett** is with the United States Bureau of Reclamation, Denver, Colo.

Television for Monitoring Stack Emission

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Monitoring generating station stack emission is one of the more difficult applications of industrial television due to the wide range in natural illumination under which it must function. An early installation, which has now been operating for 2 years, is described here.

THIS investigation of a video means for obtaining a continuous monitoring of emission from generating station stacks led to the making of trial installations of a number of types of television equipment which were available for industrial use. For several years previous, video monitoring of water level heights in boilers had been employed and found very satisfactory.

The monitoring of stack emission presented some new problems. Most industrial television applications had been made where the light intensity of the object being viewed was fixed in level and the background could be controlled to provide optimum camera tube response. The viewing of stacks under the very great range of natural illumination, thousands of foot-candles to less than 100 foot-candles, and a background which varied from a bright clear blue sky to a leaden overcast, required additional considerations which had not been met with generally in many other industrial uses of television.

In order to present a satisfactory picture over this large range of illumination, it was early recognized that some control would have to be exercised over the amount of light entering the camera pickup tube. All of the equipment then available did this by manually adjusting the iris diaphragm. Since the camera pickup would be unattended and at considerable distance from the viewing screen, it was felt that an automatic-iris-control adjustment would be preferable to remote manual control.

Three basically different types of camera tubes were compared in the original investigation. They varied in image persistance, spectral response, and estimated life. Since the color of the background, sky and clouds, presented quite a range in both color and light intensity, it would be desirable that the camera pickup tube have a spectral response similar to that of the human eye. Some types of tubes had the maximum sensitivity at the red end of the spectrum, others at the blue end. Filters were used to attempt to bring the response as near to that of the human eye as possible and still have a sensitive enough response at low light intensities.

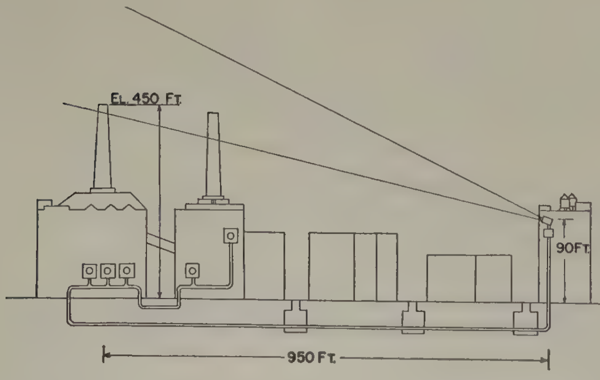

Figure 1. Television monitor of Waterside stacks

The first installations were made with the camera pickup mounted on the roof of the generating station and, in order to view the stacks, the camera pointed almost vertically upward. The operating personnel did not particularly like this angle of presentation, so in the permanent installation the camera was moved 1/4 mile away from the station.

In selecting a site for the camera pickup, it is desirable to view the stacks in a northerly direction, but in any event to so orient the camera in azimuth and altitude so that the sun will not shine directly down the lens barrel at any time during the year.

Preliminary tests with four different television systems were conducted at the Waterside generating station of the Consolidated Edison Company of New York, Inc., New York, N. Y. The camera pickups were mounted in temporary enclosures on the roof of the station and the display scope installed in one of the boiler control rooms on the ground floor of the station, a distance of approximately 400 feet from the pickup camera. A summary of the results obtained is shown in Table I.

Table I. Performance of Industrial Television Systems for Monitoring Stack Emission

	A	B	C	D
Total hours under test	350	1,800	235	220
Number of outages	4	3	0	0
Maximum continuous hours of operation	145	665	235	220
Picture resolution	Good	Fair	Fair	Very good
Fidelity of presentation of the stack emission	Good	Good	Good	Good
Minimum illumination required, foot-candles	Not determined	700	700	150
Amount of readjustment required	Frequent	Infrequent	Infrequent	Infrequent

As a result of these tests, it was decided to install the Model *D* system in all four boiler control rooms and the station general superintendent's office at the Waterside generating station, but to have the pickup camera located in one of the upper floors of a building about 1/4 mile south of

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Full text of District paper presented at the AIEE South West District Meeting, St. Louis, Mo., April 14-17, 1952.

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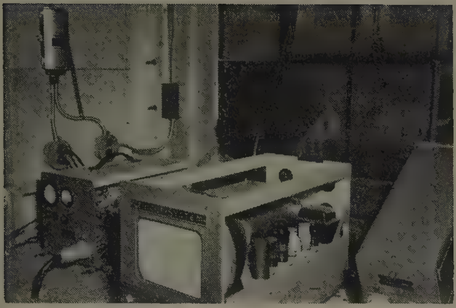

Figure 2. Power unit, control monitor, and camera unit

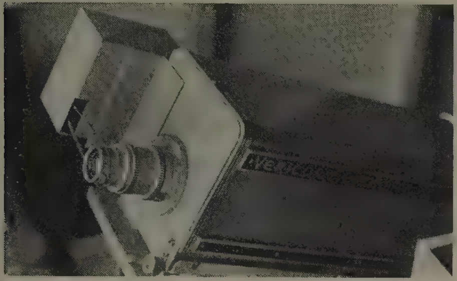

Figure 3. Camera with automatic iris control

the generating station. In order to transmit the video signal from the camera to the several display scopes, low-loss polyethylene-insulated cable was installed in the underground duct system between the two locations. Standard type *RG-11/U* cable was installed between the two locations and standard connector fittings were used to splice the cable in the manholes and at the terminating fittings. The splices in the manholes were covered with waterproof tape and the exposed cables in the manholes were then covered with portland cement arc-proofing similar to the method used to protect power cables in manholes.

The length of cable from the camera pickup to the most remote display scope is 2,000 feet. Figure 1 shows the general arrangement of the system layout.

The maximum frequency of the video signal transmitted is approximately 4 megacycles per second. A signal of about $1^1/_2$ volts peak to peak is fed into the camera end of the cable. Since the surge impedance of the cable is 75 ohms, the most remote display scope contains a noninductive line termination resistor of 75 ohms. The input to amplifiers at each of the display scopes is a high-resistance potentiometer so that their shunt impedance across the line is negligible.

The 60-cycle power supply at the camera pickup location is taken from a stabilized voltage source. This was found to be extremely desirable to insure stable automatic operation. In order to obtain minimum-cost camera-tube life, an astronomical time switch turns off the camera pickup equipment during the hours of darkness. The turning off and on of the display scopes are left to the station operating personnel who are continuously on duty at these locations.

A general picture of the camera pickup equipment is shown in Figure 2. A small monitoring scope is included at the camera pickup point in order to facilitate making electrical and optical adjustments of the video camera. The automatic-iris-control mechanism mounted on the camera is shown in Figure 3.

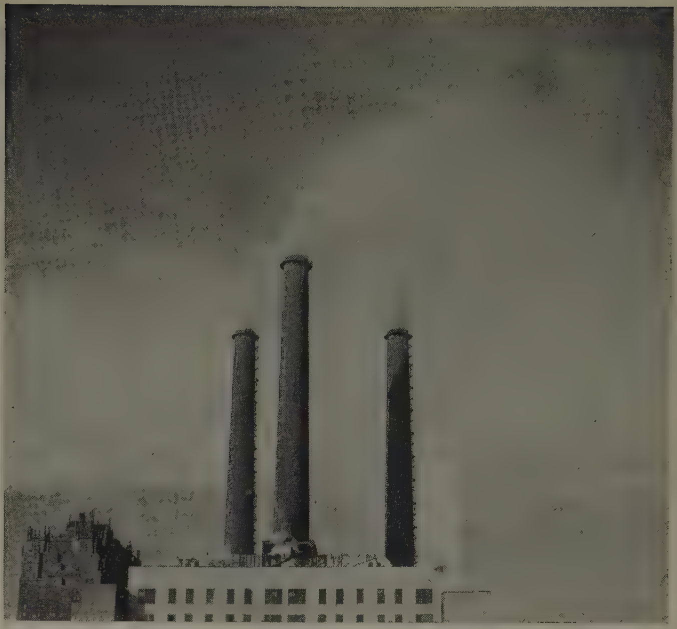

Figure 4. View of Waterside stacks from camera location

The view of the generating station stack as seen from the camera pickup point is shown in Figure 4. The display scopes at each of the four boiler control rooms in the station give a picture 10 by $7^1/_2$ inches. A typical installation picture is shown in Figure 5.

The cost of equipment to make such a stack monitoring installation was approximately $12,500. The maintenance expense on the electronic components is similar to that experienced with other electronic-operated equipment normally used in generating stations. In general, tube life of from 4,000 to 8,000 hours is usually obtained except for the video camera tube. It had been expected that the video camera tube would have about 2,000 hours of useful life. Our experience has been that their life is nearer to the 1,000-hour guaranteed life.

The system which was installed at the Waterside generating station has 94 electronic tubes other than cathode-ray and video-camera tubes. During the 2 years it has been in operation, the tube replacement costs per year have been approximately:

Type	Number Replaced in 2 Years	Annual Cost
Video camera tubes	4	$1,700
Cathode-ray tubes	2	$ 25
Other electronic tubes	114	$ 50

It will be noted that the major operating cost is due to the video camera tube which is both an expensive tube and a relatively short-lived tube. It is believed that much could be done to improve the operating performance of video camera tubes.

The television system used in monitoring stack emission for the Consolidated Edison Company in New York was developed by Remington Rand, Inc. The basic system consists of a camera, a master control monitor, and a power supply.

Figure 5. The display scope in boiler control room showing the Waterside generating station stacks

The actual component units of the basic system are shown in Figure 6. It will be noted that they are all connected together with cables to provide what is normally referred to as a closed-circuit television system operated from 115 volts, 60 cycles. In this installation, the camera was slightly modified and a special automatic electronic iris-control unit was added. This automatic iris causes the camera lens to open and close in a manner similar to the pupil of the human eye.

Recent news reports have described the use of television-equipped radio-controlled airplanes as guided missiles in Korea. This type of guided-missile operation was very successfully employed by the United States Air Force in early 1945, when robot aircraft were directed into the underground openings of the large German rocket launching sites in the Calais area of France. In these installations, it was necessary that some kind of automatic adjustment be provided to compensate for the changes in lighting conditions during flight. Such a control unit was developed under military contract by Remington Rand's laboratory and the same idea was redesigned and installed at Consolidated Edison.

In stack emission monitoring, not only does the intensity of light change but also the spectral characteristics. The function of the automatic-iris-control unit is to adjust electronically the opening in front of the camera lens to allow the most satisfactory picture to be obtained under any given intensity or color condition.

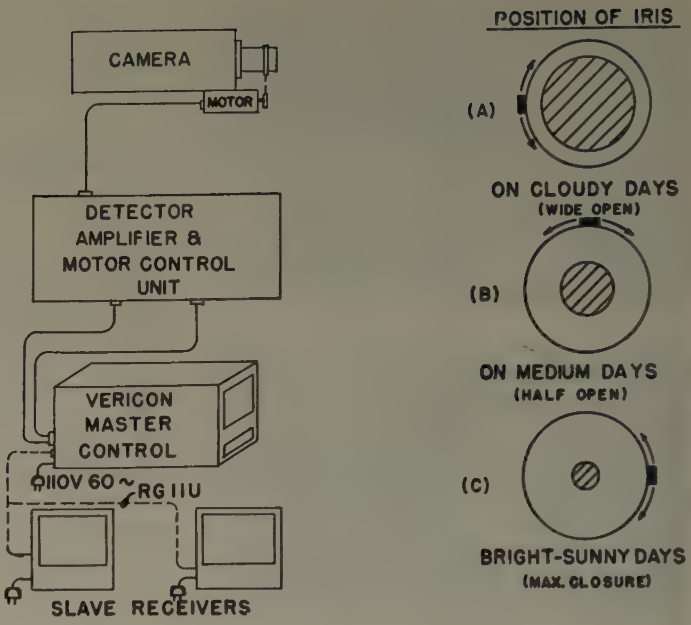

Figure 7. Television automatic-iris-control system

The manner in which the lens iris diaphragm setting is regulated automatically by an electromechanical system to maintain optimum contrast in the picture under varying lighting conditions is shown in Figure 7. The video signal is used as the source of control, with the lens iris mechanically coupled to a driving motor and operated by the circuit shown in block form. The control circuit consists of a video amplifier, rectifier, d-c amplifier, and a differential circuit for starting and stopping the motor and reversing its direction as required to give proper lens aperture. Relative iris apertures under different conditions of lighting are given in Figure 7, *A*, *B*, and *C*.

A typical Vericon system, consisting of a camera, a master control monitor with a 10-inch viewing screen, and a power supply is shown in Figure 8. You will note that the cables connect all three units together in what is termed a closed circuit. The cable from the camera to the power supply should not be longer than 100 feet, while the cable

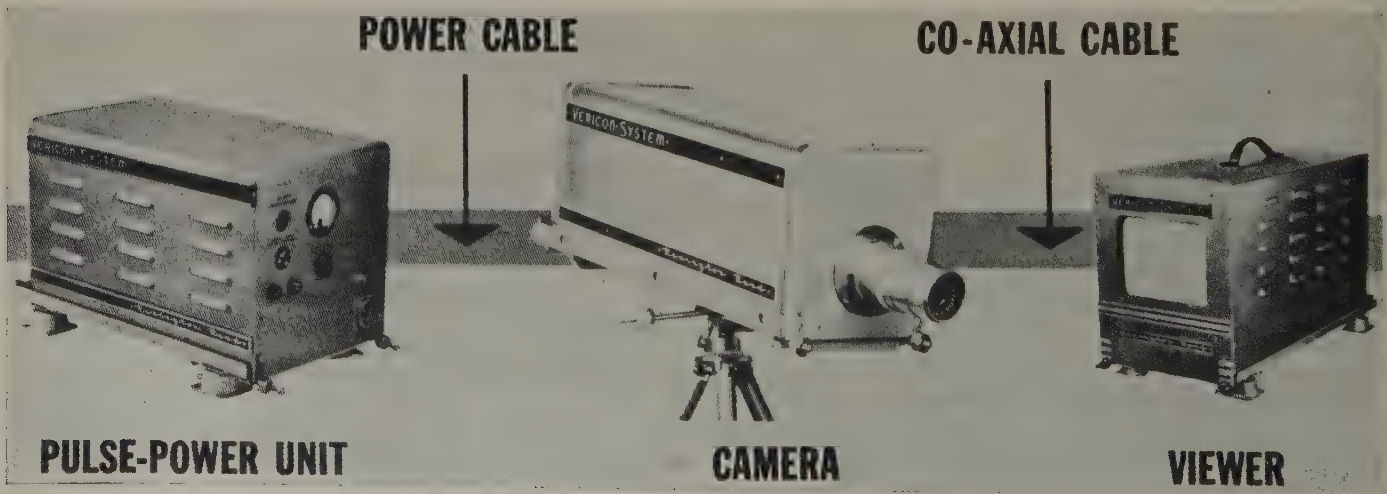

Figure 6. A basic Vericon system

from the camera to the master control monitor may be extended to 1,000 feet. A small *RG-11/U* concentric line is connected from the back of the master control monitor and extended up to 4,000 feet away. It provides video to as many as ten slave receivers. The equipment is capable of continuous operation in temperatures from −50 degrees to +120 degrees Fahrenheit. All receivers must be operated from the same 60-cycle source, since they are synchronized with the line.

The Vericon basic system for observing or monitoring stack emission consists of the three units previously described plus the automatic iris control, all installed in a special housing approximately 1/2 mile away from the stacks to be viewed.

The Vericon system differs from commercial broadcast television in certain technical respects but is capable of producing a picture of broadcast quality. Broadcast television employs 525-line interlaced scanning at the rate of 30 complete pictures each second. Unlike broadcast television, this system employs a sequential type of scanning. The scanning lines begin at the upper-left-hand corner of the screen and progress back and forth to the bottom of the screen without repeating at the rate of 60 complete pictures per second. No interlacing is employed.

The system employed in monitoring of stack emission for Consolidated Edison was installed 2 years ago and except for some initial difficulties it has operated most successfully. It is expected that this type of television observation, in connection with stack emission problems, will eventually find widespread use among industrial and utilities plants. The Consolidated Edison Company has planned several more installations for monitoring stack emission in other generating stations.

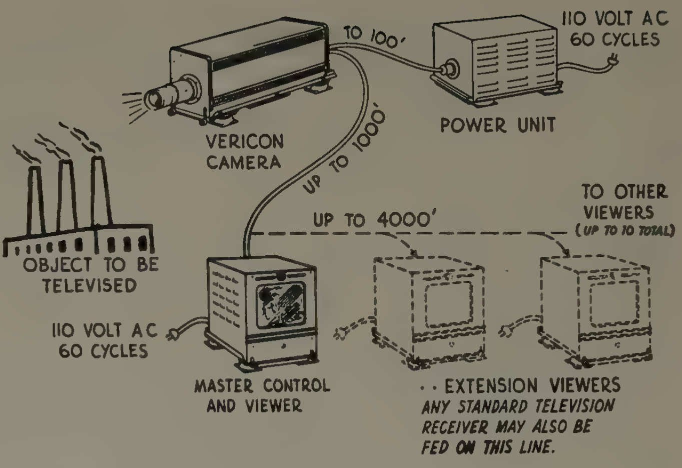

Figure 8. Typical operation with a complete Vericon assembly

Discussions on Cyclotrons, Linear Accelerators, Synchrotrons

The high-energy accelerator conference held at Brookhaven National Laboratory, Upton, N. Y., featured discussions on frequency-modulated cyclotrons, linear accelerators, and synchrotrons.

The subject of frequency-modulated cyclotrons was introduced by R. L. Thornton, Berkeley, Calif., who remarked on the simplicity and reliability of these machines. For example, the 184-inch cyclotron at Berkeley is now in operation at 95-per-cent monthly efficiency on a 20-hour day, 7-day week basis. However, the great need at present is to obtain better external beams free of the background radiation that is so troublesome when using internal targets. Only 0.1 per cent of the circulating beam is now extracted at Berkeley and that only for a few tenths of a microsecond. Changes now being planned in this cyclotron include a reduction of magnet gap and additional magnetizing coils so as to obtain 730-mega-electron-volt protons, 450-mega-electron-volt deuterons, 900-mega-electron-volt alpha particles, or 1.1-billion-electron-volt helium 3 nuclei.

C. J. Bakker of the Netherlands described the present plans for the 600-mega-electron-volt synchro-cyclotron that will be one of the main facilities in the new European laboratory to be established in Switzerland. The design specifies a magnet of 5 meters diameter, weighing about 2,500 tons. To obtain the required radio-frequency range of 34 to 17 megacycles, experiments are proceeding on an aluminum tuning fork or vibrating reed.

In opening the discussions on linear accelerators, it was pointed out that the most important advantage of proton linear accelerators over cyclotrons is the much higher intensity attainable in the external beam and the longer time over which the beam can be made available.

The relative advantages of dielectric versus metallic loading for the waveguide in an electron linear accelerator were discussed by D. W. Fry of the Atomic Energy Research Establishment, Harwell, England. Theoretically, with dielectric loading, tube diameters, and power consumption can be cut to about one-third. An experimental 3,000 megacycle guide, 80 centimeters long, $2^1/_2$ inches in diameter, was loaded with dielectric disks of dielectric constant 90 at Harwell. After some early difficulty with electron emission from oil films or other contamination on the disks, operation was in reasonable agreement with theory.

The session on synchrotrons was opened with a discussion of the construction and operation of the Brookhaven Cosmotron. After remarks that a synchrotron was no better than its magnet, the extensive design, model measurements, testing, and careful erection of the Cosmotron magnet were outlined.

Recently, a considerable amount of time has been spent in determining the factors necessary for reliable and consistent operation of the Cosmotron. A detailed study was made of the processes of injection. Close coupling between vertical and radial oscillations was observed and it is probable that this mechanism allows the protons to clear the injecting equipment after their first revolution.

Some Future Aspects of Electric Traction

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MEMBER AIEE

DIESEL-ELECTRIC LOCOMOTIVES have replaced steam locomotives in the United States to a great extent and have been used in preference to railway electrification, whereas in Europe the tendency is still rather in favor of full electrification.

One reason for this divergency is very obvious: oil, in the United States, is abundant and cheap. The European countries, practicing full electrification, have almost no oil, but possess large resources of cheap water power.

Another difference lies in the nature of railway traffic. European railways serve mostly densely populated areas, short distances apart, with relatively light trains and heavy local movement, requiring a large number of locomotives per route-mile. Manufacture of diesel-electric locomotives in Europe, on a nonstandardized basis, is expensive, and investment of fixed property character seems more economical. On American lines through service with heavy trains and relatively little local movement predominates, the number of locomotives per route-mile is limited, the expense for diesel-electric locomotives is moderate, and so their use seems logical.

Moreover, the financial structure of the railways is different. The initial investment for full electrification is very heavy, and even if it pays in the long run, money must be found. The European railways are state-owned, and a state has better facilities for procuring big sums than the American private railway companies, already heavily in debt and suffering from Government-subsidized competition.

The matter of financing and taxation plays a role too. Here the railways can secure new diesel-electric locomotives by means of equipment trust certificates, but no such way exists for investment relating to fixed property. On the other hand, in many states of the United States the investment in fixed property is taxed, but capital outlay for rolling stock is free from such charges. The decision may be influenced also by like or dislike of heavy standardization.

The heavy cost of full electrification in America is partly due to the large weight of many locomotive types. Old types had weights of about 300 pounds per horsepower, and the quite recent locomotives of the Pennsylvania and the New York New Haven and Hartford line have about 90 pounds per horsepower. European types of recent design are much lighter, around 70 pounds. The latest powerful electric locomotives in Switzerland have the extremely light weight of about 45 pounds per horsepower.

There is the legitimate objection that locomotive weights should not be compared without consideration of train weights, but it seems that the performance in drawbar-pull is not much different here than in Europe. Excess weight not only costs excess money in purchase and in nonrevenue ton-miles, it also may deprive a locomotive of the important safety factor of adhesion.

The old controversy may be reopened in the light of possible new developments. With the perfection of the mercury-arc rectifier for substation equipment a good parity between the two systems was established, but improvements may change the aspect anew, and in this respect the possibilities seem more in favor of single phase.

The most important handicap for cheap d-c electrification, namely the limitation of the trolley voltage to maximal 3,000 volts, cannot be removed at the present state of technique. A-c electrification is handicapped by the necessity of conversion from 3-phase industrial frequency to single phase at low frequency. Here decisive progress seems possible in two ways: equipping locomotives with mercury-arc rectifiers, and adapting the single-phase commutator motor to industrial frequency. Both methods have been tried with good success.

The experiments with 50-cycle single-phase locomotives with commutator motors in Germany and France induced the French to consider the generalized use of this system on their secondary arteries in spite of the complication that the same locomotives must be capable also of running on the d-c equipped main lines.

Of course, the adoption of industrial frequency for single-phase electrification creates other problems. The single-phase trolley line would have to be sectionalized and connected to different phases of the 3-phase high-voltage system, which would cause some unbalance, or phase conversion would be required. Another drawback would be the increased reactive drop in the trolley-return rail circuit. This could be remedied by raising the trolley voltage to 22,000 or 30,000 volts, which would not appear to present any serious difficulty. Still another point to be considered concerns railway signalling. Raising the frequency of the traction current to 60 cycles would force increasing the frequency of the signal currents.

Still, the elimination of the frequency conversion represents so great an advantage that a thorough investigation in the use of industrial frequency is certainly justified.

Progress in a-c electrification not only would change the balance between direct current and alternating current, but also would influence the decision between full electrification and dieselization, since the lines best suited for a-c electrification (long distances, not too much traffic density, requiring only a relatively small number of locomotives per route-mile) are also well-suited for diesel-electric locomotives.

Digest of paper 52-25, "Railway Electrification, Diesel-Electric Locomotives, and Some Future Aspects of Electric Traction," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Published in AIEE *Transactions*, volume 71, part II, 1952, pages 48–50.

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The Figure of Merit of Magnetic Amplifiers

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REGULATING SYSTEMS are a combination of devices whereby a large amount of energy is controlled by a small amount of energy. In designing regulating systems it is necessary to be able to evaluate power amplification, delay, and voltage gain of the amplifiers involved. In static and rotating magnetic amplifiers, as voltage gain is flexible, power amplification and delay define the capabilities of the amplifier. For this reason the "figure of merit" of a magnetic amplifier has been defined as the ratio of amplifier power amplification to amplifier time constant. This is expressed:

$$m=\frac{A_p}{T} \text{ per cycle or per second}$$

where m is the figure of merit, A_p is the power amplification, and T is the time constant of the amplifier in cycles of the supply frequency or in seconds.

It is possible to gain a clear physical picture of the figure of merit concept from the equivalent expression

$$m=\frac{\Delta P_o}{L_i \Delta I_i^2} \text{ per second}$$

where P_o is the change in amplifier output power corresponding to a change in signal current ΔI_i, and L_i is the effective inductance of the amplifier control circuit. The figure of merit of a magnetic amplifier can therefore be expressed as the ratio of the change in amplifier power output to twice the change in energy stored in the amplifier control circuit.

The performance of magnetic amplifiers in regulating systems may be expressed in the form of a transfer function. This function may be obtained by linearizing the magnetic amplifier and making certain simplifying assumptions. The simplified device may be more easily understood and analyzed by examining its equivalent circuit. A linearized equivalent circuit of a self-saturating magnetic amplifier is shown in Figure 1*A*. The simplified equivalent circuit is shown in Figure 1*B*.

Employing the linearizations of Figure 1*A*, the figure of merit of a magnetic amplifier operating into a fixed load is a constant over wide ranges of power amplifications and time constants. Deviations from this constant relationship occur at very low values of time constant where residual delays and the phenomenon of commutation become important. This deviation is in the region of amplifier time constants of the order of one cycle of the supply frequency. Over the wide operating regions in which these effects are negligible the amplifier figure of merit concept can be applied immediately to design considerations.

Design considerations which apply to self-saturating magnetic amplifiers can be summarized as follows:

1. The amplifier figure of merit varies inversely with the oersteds required for control.
2. The amplifier figure of merit varies directly with the ratio of load winding copper to effective length of the core magnetic path.
3. The amplifier figure of merit is independent of the saturation flux density of the core material and of core stack height (for stacked cores) or strip width (for toroidal cores).
4. Amplifiers employing high-permeability cores require a negligible amount of control winding copper as compared with load winding copper.

An expression can be derived showing the relationship of core dimensions and winding factors to the figure of merit valid within the approximations of the deviation. Calculations from this expression check measured values closely.

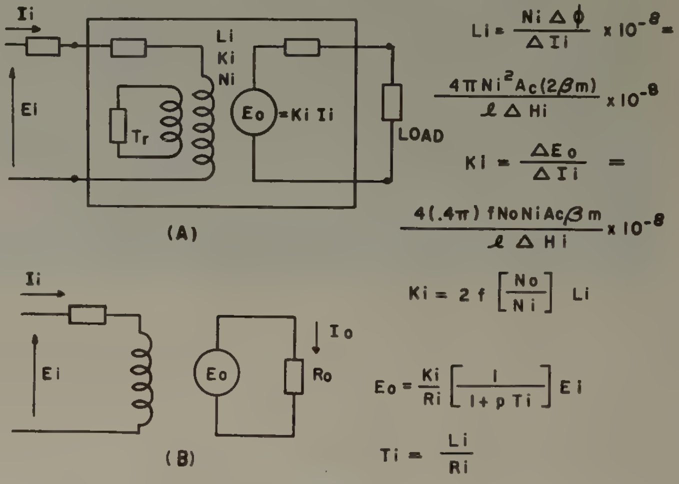
Ii
Li
Ki
Ni
Ei
Tr
Eo
=Ki Ii
LOAD
(A)
$L_i = \frac{N_i \Delta\phi}{\Delta I_i} \times 10^{-8} =$
$\frac{4\pi N_i^2 A_c (2\beta m)}{l \Delta H_i} \times 10^{-8}$
$K_i = \frac{\Delta E_o}{\Delta I_i} =$
$\frac{4(.4\pi) f N_o N_i A_c \beta m}{l \Delta H_i} \times 10^{-8}$
$K_i = 2f \left[\frac{N_o}{N_i}\right] L_i$
Ii
Ei
Eo
Io
Ro
$E_o = \frac{K_i}{R_i}\left[\frac{1}{1+pT_i}\right] E_i$
$T_i = \frac{L_i}{R_i}$
(B)

Figure 1

A. Equivalent circuit of self-saturating magnetic amplifier linearized over the Curve OA

B. Simplified equivalent circuit

The figure of merit of the series-connected simple reactor magnetic amplifier is a constant independent of core properties and dimensions over a wide range. The value of this constant is 4 per cycle of supply frequency. The figure of merit of the parallel-connected simple reactor magnetic amplifier is always less than 4 per cycle as a result of the delay imposed by the parallel connected load windings.

Digest of paper 52-234, "The Figure of Merit of Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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S. S. United States

E. E. BENZENBERG

AS AN INTRODUCTION to a discussion of the *S. S. United States*, it may be interesting to explain some of the background leading up to the decision by the Government to build ships which have national defense features included in their basic design. During and after the termination of World War II, the Armed Forces in this country learned several lessons in regard to the levels at which our Merchant Marine must be maintained if the United States was to be able to maintain successfully its own security and, at the same time, contain and defeat the aggressive actions of any potentially unfriendly nation in other parts of the world. The lesson pertinent to this discussion was that this country was sadly lacking in large, fast vessels capable of rapid conversion into troop transports. The few vessels which were available, including those loaned to us by our allies, were discovered to be lacking in vital defense features, and, because of their inherent design as passenger vessels, were also found to require costly and lengthy alterations before they could serve as transports at all. An examination of rentals paid to foreign vessels, including costs of conversion and reconversion, further showed that it was financially expensive to depend on the utilization of foreign-flag vessels under war conditions.

The foregoing, plus the possibility or even probability, that any future war might find friendly foreign nations unable to make available their own vessels for the transport of American soldiers to critical areas throughout the world, convinced the United States Navy and the Maritime Administration that in any future merchant construction consideration should be given, of necessity, to the addition of national defense features. In making this decision it was recognized that the addition of such features would penalize the shipowners from the standpoint of initial construction costs. For that reason it was agreed that the Government, through the Maritime Administration, and upon authorization by the Navy and Maritime Administration, should contribute funds toward the construction of defense features in such vessels.

In March 1946, the United States Lines decided that it would be advisable to build an additional large passenger vessel. In preliminary meetings with Governmental agencies it was agreed that the vessel should be designed and constructed basically as a naval auxiliary. As such, high speed, safety, long range of operation, and rapid convertibility from a commercial vessel to a troop transport were of prime importance while its commercial use as a passenger vessel was secondary.

Revised text of a paper presented before the Schenectady Section, November 12, 1952.

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The S. S. United States, world's foremost passenger vessel, can be converted rapidly to a troop transport capable of carrying 12,000 to 14,000 troops. It meets the fire-protection standards established by Senate Report 184 to which no other merchant vessel has ever been built. The electric installation, which is described briefly, is undoubtedly the most advanced and complex aboard any commercial vessel in the world.

The design of a large transatlantic liner is by no means an easy task, since it is necessary to deal with a dozen or more governmental agencies and regulatory bodies in addition to the owners. The *S. S. United States* project was complicated further by the interjection of hard and fast requirements of the Navy and Maritime Administration, one of the first of which was that high standards of security throughout the development of the design, the construction, and ultimately the operation of the vessel be maintained.

Navy fire-protection regulations prohibit the use of wood and stipulate that all materials used must be fire resistant. Had the *United States* been designed for use exclusively by the Navy the problem would have been relatively simple. As it had to be used as a passenger ship, extensive investigations and tests were necessary to locate or develop materials meeting the Navy fire-protection requirements which also could replace satisfactorily nonfire-resistant materials normally used in passenger vessels.

The United States Coast Guard is the agency which controls commercial vessels, and its requirements for fire protection therefore had to be included in the design. Under their regulations, then in effect, passenger ships in this country could be built in conformity with either of two standards of fire protection. One, the lower standard, to which all American flagships are designed and built, exceeds the requirements of the 1929 International Convention of Safety of Life at Sea; the other, to which no merchant vessel ever had been built, sets much higher standards, as established by Senate Report *184*. In order to meet the Navy requirements, the decision was made to use the higher standard.

Additional special fire tests solved many problems, the most important of which was that all staterooms should be furnished with materials which would not propagate a flame. These justified the previously thought-out design details proposed by the naval architects in the use of fire-resistant mattresses, drapery materials, and upholstery, and, more important, in the elimination of the highly inflammable kapok-type life preservers. In order to carry out this program, the designer, in the interest of expediency, worked jointly with the Coast Guard in the development of specifications which could be used in determining whether or not fabrics and other materials could be classed as fire resistant and thus usable.

Since there was a very limited number of fabrics which could meet these specifications, it became necessary to resort to treating fabrics with a durable-type fire-retardant chemical. Although there were numerous chemicals on the market, all but two were hygroscopic, and could not be used aboard ship. Durability of treatment was essential to insure maintenance of the flame-retardant properties even after repeated washings or dry cleanings. This treatment was successfully developed and applied, with the result that many fabrics which previously had been highly inflammable, such as cotton batting used in mattresses, and decorative fabrics, will not sustain combustion aboard the *S. S. United States*. One of the outstanding results is the substitution in all life preservers of a noninflammable glass fiber material for highly inflammable kapok.

One of the most difficult problems was that of finding an oil paint that would contain a fire without the flame "flashing" on the bulkhead, as happened in the unfortunate fire aboard the *S. S. Noronic* in Canada. Representatives of all of the leading paint companies were assembled and presented with a request that they do everything possible to work out a solution. All but one reported that they had been working on the problem for years with no success. One firm, however, developed a paint to which a flame, at a temperature of 2,300 degrees Fahrenheit, could be applied, and then removed, without the fire continuing.

When it came to choosing the proper deck covering, bearing in mind the dual purpose of having a decorative as well as fire-resistant covering, well over 100 different types were examined and tested.

The technical work was, of course, proceeding concurrently with all the investigating and testing of materials. The design of any large vessel, particularly one which will operate in the North Atlantic, is a difficult and complicated task. It represents the combined engineering efforts required in designing a cantilever-type bridge, a first-class hotel, and a public service powerhouse, plus those required in designing a sturdy watertight hull capable of operating in waters where tremendous waves, ranging in length from 300 to 600 feet, are often encountered. Added to this is the requirement that the vessel remain upright and stable.

In order to arrive at the best hull form, models were built and extensive tests carried out in tanks simulating the vessel's operation in varying sea conditions. Such tests also included model testing of the vessel in a wind tunnel to insure the best flow of air over the hull and superstructure in relation to the stacks in order to remove the stack gases from the passenger decks.

In order to minimize vibration adequately, extra stiffness was required in the after and forward end to resist the forces imposed on the vessel when running into heavy seas. The extensive use of welding aided in reducing weight and resulted in the construction of a vessel with its sides as smooth and slick as a private yacht. The designers and builders of machinery have been advancing in the art of developing more powerful engines, yet the weight of such equipment has been gradually reduced over a period of time. Since the machinery was located at a low level, it became necessary to reduce the topside weight radically. The use of aluminum helped reduce the topside weight, and had an added advantage since the lower modulus of elasticity of the material permitted the omission of expansion joints, which are always troublesome.

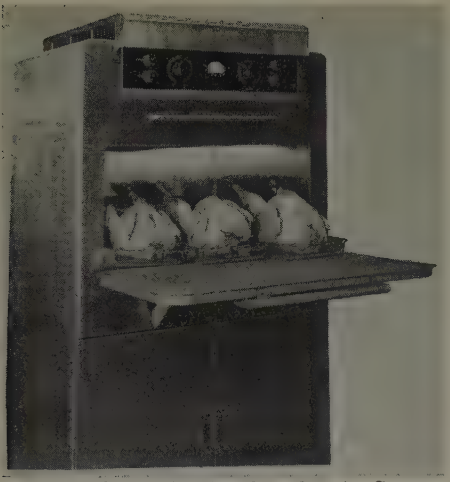


Figure 1. Radarange used in the galley of the S. S. United States

Courtesy Raytheon Manufacturing Company

In order to meet Navy requirements, and to reduce topside weight, all wooden deckings were eliminated from the weather, or exposed, decks. Neoprene latex plastic decking was substituted. This, it might be added, is a unique innovation in a passenger ship and is the first time wooden decks have been completely eliminated in any passenger vessel.

Since the *United States* was designed as a naval auxiliary, there was specified a standard of safety in regard to stability and subdivision that far exceeded the then-present minimum laws as well as the laws which have been enacted recently as a result of the International Conference of Safety of Life at Sea held in 1948.

As a further means of protecting the passengers, the ship was provided with a safety room. This space, which is akin to the damage control center on a naval vessel, is the focus for safety features and in the event of an emergency the complete picture of the ship's condition can be seen at a glance and the necessary countermeasures taken and instructions given.

The arrangement of the ship was, in itself, a problem when one considers that approximately 2,000 passengers and 1,000 crew members must be provided all of the facilities normally available to them at home.

Consistent with developing a modern design, air conditioning was provided for all accommodations, crew and passenger alike. The design provided for individual control of temperature in each room. This was accomplished by a chilled water system, with a cooler serving a bank of rooms and with each room having its individual heater, usually located in the bathroom overhead, behind a hinged panel.

The propulsion machinery installation, representing the combined efforts of numerous designers, manufacturers, and the shipbuilder, is the last word in very modern high-pressure high-temperature machinery. It is so efficient that it permits the ship to attain high speeds while using even less fuel than is expended in other passenger vessels of comparable size at much lower speeds. Thus the *S. S. United States*, as a troopship, could deliver rapidly almost a division of troops to nearly any port in the world and return to the United States, a round voyage of about 10,000 miles, without stopping for fuel, water, or supplies.

In order to make the vessel self-sufficient in its operation, not only as a passenger vessel, but particularly as a troop transport, distilling plants have been provided to furnish the purest type of water required for the operation of the boilers and for drinking purposes.

The electrical phase of the design was an unusually complex and important one, particularly because of the important role electric power plays in the operation of the ship, its safety, and in providing facilities for the comfort and convenience of the passengers.

Of course, the *S. S. United States* must generate its own power and maintain a service so reliable and flexible that there can be no failure even in the case of a shutdown of one or more of its generators, or of a circuit interruption to some of its feeders, since no modern ship can operate without sufficient electric power.

The ship's service power is alternating current, a deviation from the conventional that aided materially in reducing weights. Other important advantages in the use of alternating current are the reduced maintenance necessary on squirrel-cage induction-type motors, and the ability to apply extensively simple across-the-line a-c controllers.

Some motor-driven auxiliaries which do not function satisfactorily on alternating current because of the inherent lack of simple, wide-range speed control under varying load conditions—among them cargo winches and elevators—are run on direct current supplied by especially adapted motor-generator convertors.

The a-c generators, which provide ship's service power, together with their associated control switchboards, were so located as to minimize the possibility of simultaneous damage to the several units. The ship's service lighting system, small and fractional-horsepower motors, and other appliances were arranged to operate at reduced voltage, obtained from the ship's service power sources through banks of transformers located at several electric load centers. Normal and alternate feeders were provided at the load centers to insure continuity of service in the event of interruption to the normal supply.

In the event of failure of all or part of the ship's service electric generating plant or distribution system, a completely separate emergency power system automatically takes over, providing the illumination necessary for the safety of the personnel, and operating certain vital communications and damage control equipment. Storage batteries supplying current to special a-c–d-c units temporarily take over during the interim while the emergency diesel-engine-driven generators are coming up to speed and while the automatic transfer operations are taking place.

Inasmuch as the over-all electric installation aboard the *United States* is undoubtedly the most advanced and complex such installation aboard any commercial vessel in the world, it may be of interest to outline briefly some of the major auxiliaries and devices dependent on it.

The elevator installation comprises 19 automatic elevators, 10 of which are for passenger use, and the remainder for cargo freight, food, and luggage, and for engineering and deck officer personnel. The combined capacity is

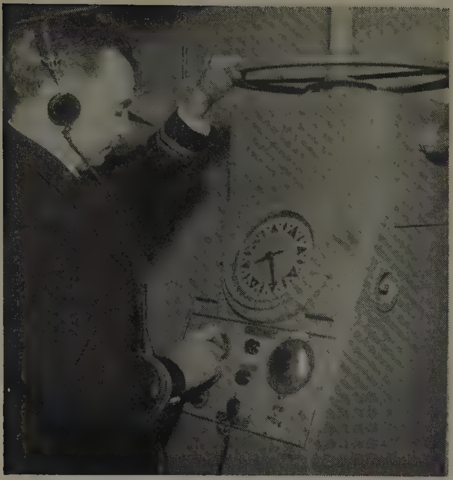


Figure 2. Radio operator checking the radio-direction finder

Courtesy Radiomarine Corporation of America

over 30 tons, and the total lift is approximately 1,000 feet. The elevators are equipped for operation by either the passengers or regular attendants. All elevators are equipped with "full-collective" controls, which "remember" all calls, answering all "up" calls on the up trip, reversing direction at the top, and answering all "down" calls on the down trip.

The boat davits, featuring new developments in trackway and releasing gear, are powered by a-c motors, and are provided with conveniently arranged push-button stations, emergency stops, and limit switches acting in a specially designed control circuit.

The cargo winches installed on the *United States* were selected because each pair of winches has its own motor-generator set, resulting in maximum operating efficiency.

The electric galley and commissary equipment is very extensive, since at least 9,000 meals must be served each day. Radaranges, see Figure 1, several of which are installed aboard the *United States*, are among the more unusual pieces of electric galley equipment. By means of the high-speed cooking inherent in the Radarange, the chef can fry an egg in 12 seconds, pork chop in 50 seconds, bake an apple in 1 minute, reheat a pie in 10 seconds, or prepare a ham and egg sandwich in 25 seconds.

To give some idea as to the magnitude of the electric installation the following figures may be of interest:

Cable. More than 50 miles of power feeders alone, not counting the vast amount of control wiring.

Circuit Breakers. More than 1,300, many electrically operated.

Fused Tumbler Switches. Approximately 700.

Motors. More than 2,300 ranging up to 400 horsepower.

Switchboard Meters Instruments. Approximately 150.

Galley and Commissary. Approximately 250 ranges, ovens, griddles, fry kettles, toasters, waffle irons, broilers, and miscellaneous motor-driven units such as slicers, dishwashers, mixers, blenders, cutters, extractors, choppers, and peelers.

The basic mandates controlling the lighting arrangements aboard the *United States* were that the lighting installation should be effective and efficient, unobtrusive, concealed wherever practicable, flexible, safe, harmonious with the surroundings, and pleasing to the user. As a result the lighting is mixed. Incandescent lighting is used in living and working spaces, while passageways, stairhalls, and stairways are lighted by fluorescent tubes having color temperature known as soft white. This color was selected because it brightens reds and tans and gives an attractive color rendition to "make-up," an important item to the women passengers. The illumination requirements of this installation are met by some 34,700 incandescent lamps and fluorescent tubes, connected by 70 miles of cable.

The ship's radio transmitters and receivers cover all of the frequencies which have been allocated to commercial use on the North Atlantic. Ship-to-shore radiotelephone apparatus permits a passenger in any stateroom on the ship to place a telephone call to almost any other telephone in the world. Entertainment radio receivers located in a central control station provide, in public spaces and recreation areas, a selection of commercial broadcast entertainment, and entertainment in the ship's ballroom can be made available in turn to land radio stations for rebroadcast.

Centralized within the safety room, which is manned on an around-the-clock basis, are the controls and warning mechanisms of the various indicating and alarm systems which help to maintain the high standards of safety afforded to all aboard the *United States*. Among them are those for fire detection-smoke and thermostatic manual and automatic fire alarms, carbon-dioxide fire-extinguishing system, fire screen doors, watertight doors, air-conditioning systems, various emergency alarms, annunciators, and telephones.

Some of the important navigation and communication installations aboard are as follows:

1. Two master gyroscopic compasses with a large number of repeater compasses.

Courtesy Raytheon Manufacturing Company

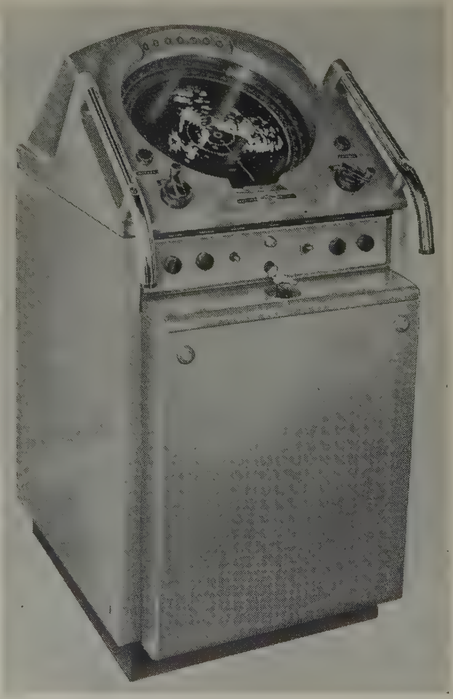


Figure 3. Mariners Pathfinder 16-inch presentation radar indicator

2. Two loran units, a Decca navigator, and a radio-direction finder. See Figure 2.

3. Two radar units, one a 3- and the other a 10-centimeter wavelength, each with simultaneous scope presentation in bridge and chart room. See Figures 3 and 4.

4. Gyroscopic pilot for automatic steering control. See Figure 5.

5. Echo sounding equipment for recording depth of water and charting the ocean floor.

6. Pitometer log for speed indication.

7. Rudder angle and shaft revolution indicator.

8. Sound-powered telephones for ship's personnel.

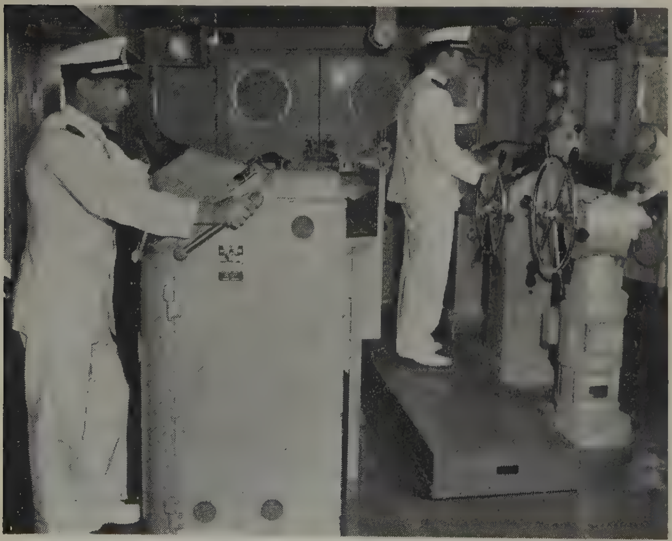
9. Manual telephones for passenger use.

10. Call bell system in each stateroom and public space for the convenience of the passengers.

11. Automatic dial telephones for communication between ship's operating departments.

12. Announcing and public address systems.

The use of new materials and equipment was not limited to the construction of the vessel alone. During the trial trips a new speed-measuring device called Raydist was used. It was developed by the Hastings Instrument Company, Hampton, Va. It was the first recorded trial trip on which such a device was used, and it gave the most accurate measurements of a ship's speed ever recorded. In the past, trials were run close to shore within sight of two markers located a nautical mile apart. The only two such measured-mile courses on the Atlantic Coast are located in Maine and Cuba. It was recognized that if either of the courses were used, which would have consumed considerable time and money in extra traveling, any person aboard the vessel during the trials could check the speed of the ship, within certain limits, by observing the shore markings. It was therefore decided to use the Raydist system during the trials. At the time of the trials, a Coast Guard cutter proceeded to deep water where an electronically equipped buoy, which was not anchored to the bottom, was dropped overboard. The *S. S. United States* was then steered away from the buoy in different directions and later turned around and headed back to it. In spite of near-hurricane weather, the trials were eminently successful, and the *United States* moved through the high seas as though she were riding in a mill pond. The small bow wave, the small amount of water thrown forward at such high speeds, the markedly small amount of pitching and rolling—all justified the many model tests carried out during the early development of the design.



Courtesy Sperry Gyroscope Company

Figure 4. View of bridge of S. S. United States showing at left the 3-centimeter radar receiver, and two special steering systems at right

On her maiden voyage, the *United States* averaged better than 35 knots for the combined east and west crossings, breaking all speed records and capturing the Blue Ribbon of the North Atlantic, which had not been held by this country for 100 years.

This average speed is equivalent to a land speed of more than 40 miles per hour. This may appear to be a low speed in comparison to a modern automobile, but when one considers the fact that the vessel is equivalent in length to five city blocks, the feat is stupendous.

During her first ten round voyages the *United States* has averaged approximately 31 knots, a speed which never before has been approached by a ship over such a distance. This is particularly interesting when it is realized that this is equal to $2^1/_2$ times around the world, and exceeds the best announced single-day run for the *Queen Elizabeth*. In other words, the *Queen Elizabeth* had not been able to maintain for a full day a speed that the *United States* has been able to maintain successfully for ten round voyages. This is also interesting when compared to the speed attained by the *Queen Mary* when she made her record one-way crossing, 31.69 knots, only about two-thirds of a knot faster than the sustained average of the *United States*.

To give an idea of the vessel's ability to travel in bad weather, on one of her recent voyages the wind was so strong that a larger European liner travelling the same course practically "hove to" for repairs at sea, since she had 18 airports broken and had certain of her passenger accommodations flooded. The *United States*, meanwhile, maintained a cruising speed of well over 30 knots, since she sustained damage of only a superficial nature.

Here are a few statistics which may be of interest:

Length over-all—990 feet (140 feet higher than 70-story Rockefeller Center)
Beam—101 feet, 6 inches
Depth—Keel to top of superstructure, 122 feet
Keel to top of stack, 175 feet (equal to a 12-story building)
Stacks—largest in world; all aluminum; 55 feet high; 60 feet long
1,500 miles of welding

Several additional points may be emphasized in regard to her dual-purpose existence. This country, in its desire for self-preservation, must supply itself with a constantly changing armory of weapons. The primary purpose of these weapons is either to deter an enemy before he commits an act of aggression or to contain and defeat him after the commission of an aggressive act. Of what use are tanks, big guns, rifles, and most of the other weapons, if they, and the men who use them, cannot be brought into prompt and

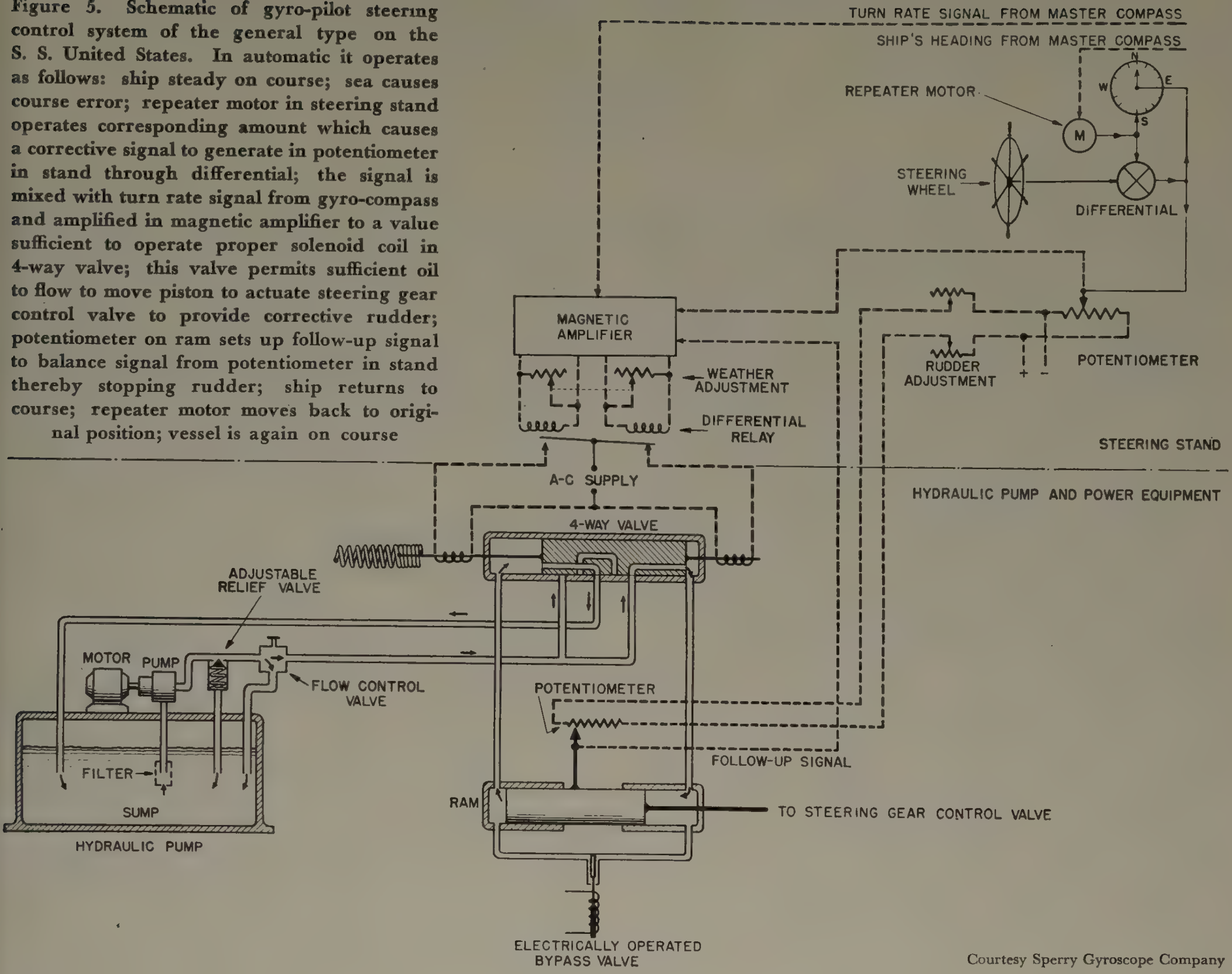


Figure 5. Schematic of gyro-pilot steering control system of the general type on the S. S. United States. In automatic it operates as follows: ship steady on course; sea causes course error; repeater motor in steering stand operates corresponding amount which causes a corrective signal to generate in potentiometer in stand through differential; the signal is mixed with turn rate signal from gyro-compass and amplified in magnetic amplifier to a value sufficient to operate proper solenoid coil in 4-way valve; this valve permits sufficient oil to flow to move piston to actuate steering gear control valve to provide corrective rudder; potentiometer on ram sets up follow-up signal to balance signal from potentiometer in stand thereby stopping rudder; ship returns to course; repeater motor moves back to original position; vessel is again on course

Courtesy Sperry Gyroscope Company

effective contact with the enemy? The weapon that transports these men and their equipment—speedily, safely, and fit to fight—to a vital spot therefore becomes of great value and importance. The *S. S. United States* is just such a weapon, capable of transporting, on a moment's notice, nearly 14,000 men to almost any port in the world.

The over-all final cost of the *United States* has been reported as approximately $72,000,000. Of this amount the owner, the United States Lines, is paying $29,000,000, the amount fixed by the Maritime Administration as the cost of building a comparable vessel without any national defense features in a foreign shipyard. The Maritime Administration is paying $19,000,000 to cover the extra amount that it cost to build this ship, without defense features, in an American shipyard, using American labor and materials, and helping to keep healthy America's vital shipbuilding industry. The many National Defense features built into the *United States* were estimated to cost $24,000,000, and this cost was approved by the Navy.

Recently several governmental agencies have criticized the original contract under the terms of which the Government paid such a large amount toward the building of the *United States*. During World War II this country had to pay for each serviceman carried to and from foreign soil on all ships owned by our allies. It has been stated that these payments amounted to approximately $1,000,000 for each voyage made by the *Queen Mary* and the *Queen Elizabeth* in this service. Simple arithmetic shows that the *United States* could pay for herself, under war conditions, in a remarkably short time.

Nearly all of the weapons used in war are paid for in whole by the Government, but this is not the case with the *S. S. United States*. Her owners have the right to operate her during her peacetime life. They also are bound to maintain her in a state of constant readiness, and she may be reclaimed whenever the Government so desires. She may never be sold without permission of the Government, and then not at a price higher than was paid for her. Finally, during her peacetime use as a passenger liner she is an aid to the economy of this country through the money she earns and through giving employment, directly and indirectly, to thousands of American citizens, and any profits over a reasonable amount are recaptured by the Government.

In conclusion, it can be said with real pride that modern American ships are the world's safest, and the *S. S. United States* far exceeds any of the others while having unique value for national defense.

Electrostatic Precipitator Pulse Power Supply

H. J. WHITE
MEMBER AIEE

IT IS NOT SURPRISING that the fundamentally important advances in the electrostatic method of separating suspended particles from gases have resulted primarily from improved methods of supplying high-voltage power. Much recent research in the electrostatic collection of particles has been directed toward improving and stabilizing electrical energization, both in connection with conventional rectifier equipment and in the development of entirely new methods of supplying electric energy. Conventional methods of supplying high-voltage power to precipitators stem directly from Cottrell's pioneer work, and essentially comprise transformer and rectifier equipment, usually with unfiltered output.

A fundamentally new system of supplying high-voltage power to Cottrell-type precipitators is based on the uses of pulse principles and techniques, and therefore may be conveniently designated as "pulse energization." The fundamental basis of the new system may be stated as follows: In electric precipitators maximum particle collection is obtained when the electrical forces acting on the particles are made as large as possible. Collection efficiency depends on both the magnitude and the shape of the applied voltage wave, with maximum operating voltages always limited by sparking in the precipitator. Steady or pure direct voltage has a relatively low sparking value and is therefore unsuited for most precipitator applications. Both the full-wave and half-wave unfiltered or pulsating rectified voltages have higher sparking values and are much more stable in operation. But valuable as the full-wave and half-wave voltages have proved to be, their characteristics are arbitrarily limited by the 60-cycle alternating voltage from which they are derived. The pulse method, on the other hand, is designed so that both the duration and frequency of the current pulses supplied are subject to precise adjustment and control, which in turn provides maximum precipitator performance.

The new equipment essentially comprises a high-voltage high-power pulse generator, capable of supplying high-voltage pulses of the order of 100 microseconds' duration at a frequency of several hundred pulses per second, which in turn may be commutated to as many as four or more precipitator sections. The method provides several basic advantages as follows:

1. Higher peak voltages and increased precipitator efficiency.
2. Inherent current-limiting action during precipitator spark-over, due to the pulse circuit used.
3. Greater degree of electrode sectionalization.
4. Higher over-all electrical efficiency.

In some respects the new pulser equipment is similar to that developed for use with high-power microwave radar equipment used during the war. The basic circuit is that of the line-type pulser in which energy is accumulated in a capacitor over relatively long periods and then discharged rapidly into the load, so that the output consists of a series of uniformly spaced high-power pulses.

A schematic diagram of a commercial pulser set designed for use with fly ash and similar precipitators is shown in Figure 1. The set is rated at 70-kv peak voltage, 300-milliampere average current, 15-kw average power, 480-cycle pulse frequency, and 150-microsecond pulse duration. Four commutated outputs are provided which permit operation of four separate high-tension precipitator sections from one set. The electrical operation of the pulser is characterized by a desirably high over-all efficiency of about 70 per cent, and by a flexibility of power output, pulse frequency, and pulse duration. Pulse frequency is easily varied by means of a variable-speed motor on the rotary spark gap. Precipitator sparking is reflected in the pulse circuit by a momentary increase in the pulse discharge current, but with proper adjustment this produces little or no effect in the charging circuits.

Extensive field tests of the effectiveness of the pulse system of energization have been made on a representative fly ash precipitator. These tests were carried out over a period of about 1 year and included many direct comparisons with the conventional rectifier equipment which was a regular part of the precipitator unit. Briefly, it was found that for the same degree of sparking in the precipitator the peak voltage was several kilovolts higher and the corona current 20 to 35 per cent higher for the pulse system. The higher permissible operating current and voltage in turn led to improved precipitator efficiency. The actual precipitator loss was reduced by 50 to 60 per cent when using the pulse system as compared with the ordinary rectifier system. The reliability of the pulse method and equipment has been satisfactorily tested by continuous operation in an experimental unit on a large fly ash precipitator for a period of more than a year.

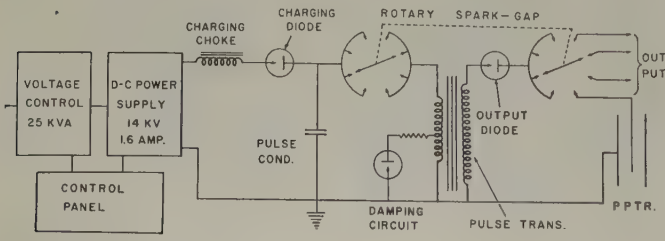


Figure 1. Schematic diagram for experimental pulser set

Digest of paper 52-230, "A Pulse Method for Supplying High-Voltage Power for Electrostatic Precipitation," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

H. J. White is with the Research Corporation, Bound Brook, N. J.

Stabilization Templates for Servomechanisms

O. J. M. SMITH
MEMBER AIEE

IN THE PROCESS of design, the engineer must consider the change in the system transfer function due to corrective networks added in cascade. Instead of a trial and error adjustment of the network parameters, templates for different corrective networks and prototype systems are drawn, which show the change in gain and phase.

The templates are used with transfer function plots on co-ordinates of decibel gain versus angle. These co-ordinates are used for the display of the open-loop transfer function of a servomechanism, so that the addition of stabilization networks can be shown as loci. Any cascaded network will have for each frequency a specified angle shift and a specified change in gain. These can be represented by a particular length of line on this co-ordinate paper.

The template of the gain-phase shift of the stabilizing network can be used with other types of transfer functions by moving it laterally or vertically. The intersection of the template and the transfer function gives the parameters of the system and the upper end of the template gives a point through which the new stabilized system will go. If the shape of the actual transfer function at high frequencies is similar to that of the prototype, then the shape of the stabilized system at the critical frequency will also be similar to that of the prototype.

An open-loop transfer function of an integral with one time constant is shown in Figure 1. Dimensionlessly it is $G_s=\theta_0/\theta_e=K/ju_1(1+ju_1)$. All of these functions are identical except that they occupy different vertical positions depending upon the value of K.

If the original system were cascaded with a lead network, whose low-frequency time constant equals that of the system's, then these time constants would cancel and the resultant system would also appear to be an integral plus one time constant. If additional gain were added, and then the transfer function expressed in dimensionless form, it would have an optimum adjustment at $M=1.3$ or $K=1.36$. Figure 1 shows this optimum or compensated prototype system.

Consider the requirement of stabilizing a system whose required d-c gain is so great that the transfer function represented by the foregoing equation cuts through the $M=1.3$ contour. Use a lead network with a ratio of time constants of k and an additional gain of k. The transfer function of the composite system is $G_cG_s=K(1+j\omega kT_2)/ju_1(1+ju_1)(1+j\omega T_2)$. To cancel the numerator factor, let $\omega kT_2=u_1$, and $\omega T_2=u$. This compensated system should go through the point A, a gain of one at 135 degrees lag. If G_cG_s is set equal to $(-0.7 - 0.7j)$ at a value of u of unity, K/k is 1.4.

The transfer function of the original uncompensated system at $u=1$, the critical frequency of the compensated system, is $G_{so}=1.4/j(1+jk)$. This is the equation for the locus of all of the points on Figure 1 which can be moved to point A by a single lead upper crossover frequency. This locus is plotted; it has only one parameter, the ratio of time constants of the lead network. The intersection of any unstabilized curve with this locus yields the values of k and u_1 for the upper crossover frequency of the lead network. The design is therefore complete.

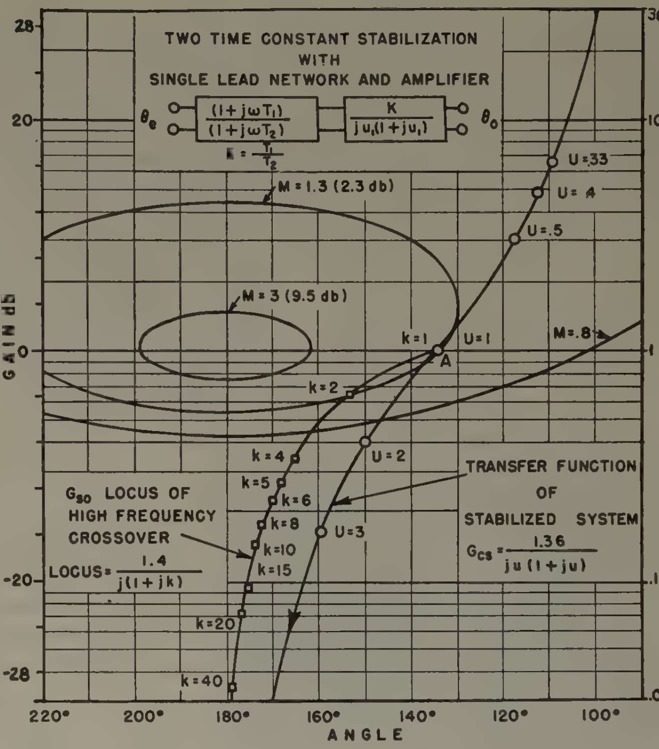


Figure 1. Locus of the change in gain and phase produced by the upper crossover frequency of a single lead network

If the original system were stable, but the speed of response not sufficient, the original transfer function should be plotted on transparent paper, laid over the template of Figure 1, and then moved in a vertical direction until the intersection of the stabilizing locus and the original transfer function occurs at the desired new critical frequency or new resonant frequency. The intersection gives the lead network design and the vertical shift is the additional d-c gain in decibels required.

A lead network was used here for illustrative purposes because of its simplicity. Templates can also be made for networks for reducing noise susceptibility, and for complex pole-zero pairs. These templates aid greatly in the rapid and systematic design of feedback systems.

Digest of paper 52-239, "Stabilization Templates for Servomechanisms," recommended by the AIEE Committee on Feedback Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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New Side-Break Outdoor Disconnecting Switch

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BASICALLY, outdoor switches must operate successfully under all circuit and atmospheric conditions. A new side-break type of switch has been designed incorporating novel contact construction in order to be comparable with modern vertical break switches without flexible braids, assuring long trouble-free life, easy operation, and maintenance. Important design specifications are

1. Moving parts should be protected from the entrance of dirt or foreign matter.
2. Suitability for operation under ice conditions.
3. The switch should have silver contact surfaces and use pressures which serve to eliminate galling of the silver.
4. No flexible braids should be used in the switch.
5. The switch should conform with National Electrical Manufacturers Association (NEMA) test requirements.

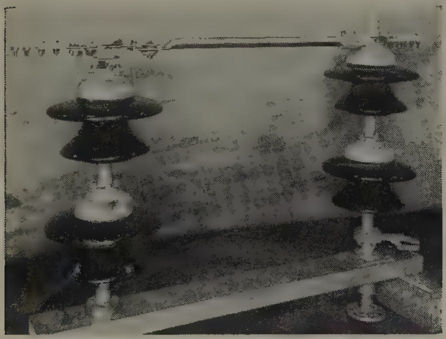

Figure 1. Single-pole unit of new design side-break disconnecting switch

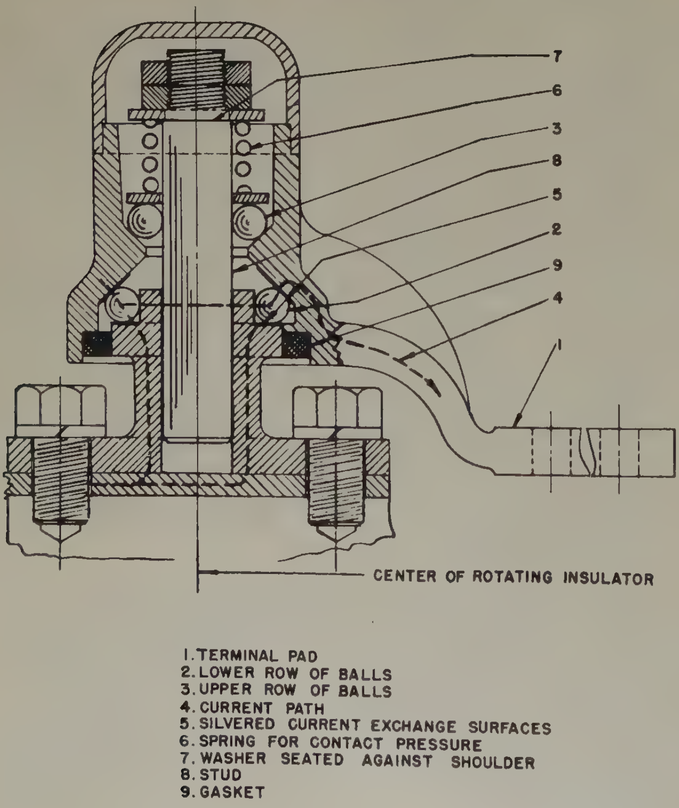
7
6
3
8
5
2
9
4
1
CENTER OF ROTATING INSULATOR
1. TERMINAL PAD
2. LOWER ROW OF BALLS
3. UPPER ROW OF BALLS
4. CURRENT PATH
5. SILVERED CURRENT EXCHANGE SURFACES
6. SPRING FOR CONTACT PRESSURE
7. WASHER SEATED AGAINST SHOULDER
8. STUD
9. GASKET

Figure 2. Cross-sectional view of hinge contact

The side-break switch, Figure 1, has three major parts: a hinge contact, a "broken back" blade contact, and a stationary contact; all arranged to co-operate.

The hinge contact, Figure 2, has two rows of silvered balls. The lower row is the current path from the blade to the terminal support. Contact pressure is maintained by a spring. The broken back blade joint is a ball and socket providing an annular line contact permitting restricted movement of the blade.

The main contact has spring-backed contact shoes with two semispherical surfaces which span from the movable blade to the stationary terminal bar. This arrangement allows for some misalignment of the blade. The contact is changeable for right- or left-hand blade opening.

An operating life test for 3,500 operations was made with a weight of 100 pounds on the terminal pad. After the life test, high-voltage short time-current tests were successfully made at the standard NEMA ratings.

A 69-kv switch was submitted to ice tests. The switch was frozen open and also closed and successfully operated. The switch was given a preliminary wetting for 1 hour. The temperature was lowered to 20 degrees Fahrenheit with continued spraying. After spraying for 5 hours, ice 1-inch thick was obtained. The force required assures operation by a man with a direct-connected mechanism.

The following may be concluded:

1. The hinge contact is completely enclosed. The "broken back" and the main contacts are protected.
2. The design assures proper functioning under ice conditions.
3. The stationary contact arrangement co-operates with the ball and socket design to allow for misalignment at installation.
4. The self-adjusting spring pressure contacts are not affected by short circuits within NEMA ratings. Multiple contacts with rolling surfaces minimize wear. The silver contacts prevent oxidation which is difficult to remove from plain copper.
5. The novel design of the movable parts eliminates flexible braids.
6. Tests prove the switch conforms with all standards.

The new braidless switch with its improved contact design will assure successful operation under adverse current and atmospheric conditions.

Digest of paper 52-49, "New Design Concepts Applied to a Side-Break Outdoor Disconnecting Switch," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in *AIEE Transactions*.

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Certain Physiologic and Pathologic Effects of Microwaves

J. F. HERRICK F. H. KRUSEN

The primary physiologic effects of microwaves appear to be due to the heating and are accompanied by an increase in the flow of blood. However, several undesirable effects were noted in connection with treatment of the eye, the most serious being the formation of cataracts. Other cautions necessary in the therapeutic application of microwaves are presented.

THE PROBLEM OF investigating the possible use of microwaves for medical diathermy was presented to the research laboratory in the spring of 1946. That microwaves could heat dead tissues was known. The Raytheon Manufacturing Company had developed microwave generators for cooking meat and other foods. Living tissues are lossy dielectrics because they contain considerable amounts of water and, consequently, would be heated easily. The question then was whether or not the temperatures desired for therapy could be maintained and controlled. Furthermore, contraindications in the use of microwaves for therapy had to be discovered. It would be most unfortunate to learn from the patient that a new therapeutic agent has deleterious effects when the discovery of such untoward effects could have been made by a thorough experimental investigation.

TISSUE HEATING AND BLOOD FLOW

THE IMMEDIATE PROBLEM was to determine what temperatures were produced in living tissues by microwaves. In medical diathermy, the physician wants not only to raise the temperature of bodily tissues to the optimal level but to maintain this level for a period sufficiently long to produce the effect desired for therapy. Preliminary experiments to study new agents of this type are made on suitable experimental animals, trained dogs in this case.

The equipment used in these investigations was procured through the generosity of the Raytheon Manufacturing Company. The cavity magnetron tube was used for generating continuous microwaves. The frequency of the equipment was 2,400 to 2,500 megacycles. The maximal output of the generator was 125 watts. The microwave energy was directed toward the patient through a director (antenna with reflector). Three types of directors designated as *A*, *B*, and *C* have been designed for general use in therapy, see Figure 1. The surface heat patterns of these directors were determined by measuring the temperatures developed in dead tissue. Directors *A* and *B* have similar surface heat patterns. Maximal heating occurs in a region intermediate between the center and the periphery. The maximal heating region for director *C* is in the center. The thigh of the dog proved to be a convenient and suitable site for studying temperatures produced in the skin, subcutaneous tissue, and muscle. Figure 2 shows the surface heat pattern of director *A* superimposed on the thigh of the dog. Meticulous care was taken to determine the region where the maximal, 100 per cent, surface heating occurred as the thermoelements for measuring temperatures were inserted there.

Practically any desired temperature can be produced in the various tissues of the thigh of the dog by properly controlling the output of the microwave generator and the duration of exposure. A very interesting phenomenon was observed which occurred repeatedly when the experimental conditions were the same. The temperatures of the various tissues begin to rise as soon as the microwave energy is directed toward them. The rise continues until approximately 20 minutes have elapsed whereupon the temperatures begin to fall. During all this time the output of the microwave generator remains constant. Obviously some heat-dissipating mechanism comes into action. Such a dissipating mechanism could be an increased circulation of the blood. Measurements of blood flow in the thigh of the dog showed that a marked increase in the flow occurred approximately simultaneously with the fall in tissue temperatures,[1] see Figure 3.

When the animal experiments had established the suitability of microwaves for heating living tissues, similar investigations were conducted on human subjects. Measurements of temperature and blood flow were made on an extremity. The results of the studies on the dog were duplicated in man.[2] Maximal temperatures were reached in man at approximately the same time that the maximal temperatures were attained in the dog under similar conditions. With continued heating the temperatures also began to fall, see Figure 4. Simultaneous with the fall in tissue temperatures, the blood flow through these tissues increased markedly, see Figure 5. In man, control observations made on the opposite unexposed extremity showed no significant changes in temperature or blood flow.

Apparently the temperature of the tissues "triggers" a mechanism which causes an increase in the flow of blood through the tissues. This is an important mechanism for preventing the development of too high temperatures. The time at which the temperature of the tissues begins to fall may vary with the output of the microwave generator

Revised text of a conference paper presented at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952.

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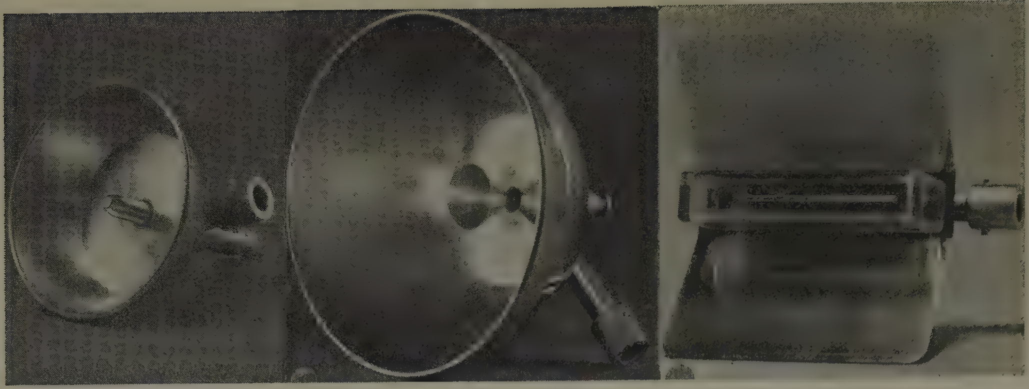

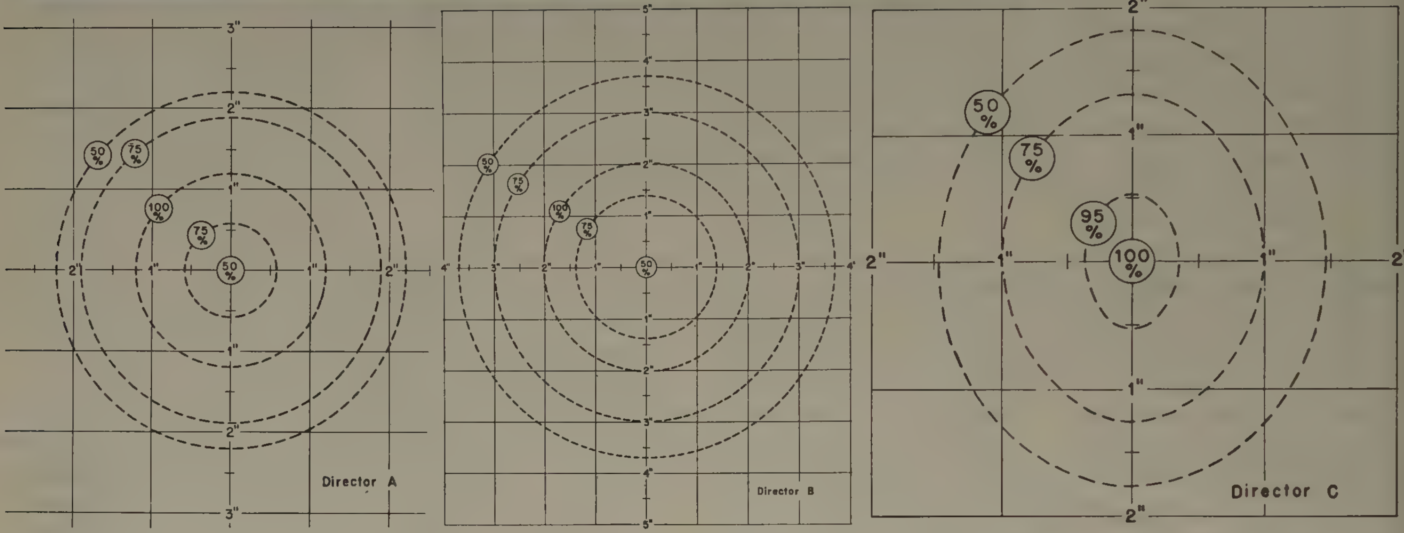

Figure 1 (left). Director A, with a 4-inch diameter, and its surface heat pattern when spaced 1 inch from skin. (Center) Director B, with 6-inch diameter, and its surface heat pattern when spaced 2 inches from skin. (Right) Director C and its surface heat pattern when spaced 2 inches from skin

and the type of director. Maximal temperatures were attained at the end of 10 minutes when using director *C* on dogs,[3] see Figure 6. Investigators at the University of Iowa found similar results when using director *C*.

Emphasis is placed on similarity of the results of studies on the dog to those on man. Much reliable data can be obtained in the field of experimental medicine, thus avoiding extensive studies on human subjects.

EFFECTS ON CONSTITUENTS OF THE BLOOD

An investigation of a new type of medical diathermy should include a study of the possible changes which may occur in the elements of the peripheral blood following exposure to the new agent. The rat seemed to be best suited to this study because considerable information has been accumulated, over many years by various investigators, on the blood changes in the white laboratory rat.

Fever was induced in the rat by the microwaves. A body temperature between 41.0 and 41.5 degrees centigrade was maintained for a period of 1 hour. There was a marked decrease in the number of eosinophils and lymphocytes and a marked increase in the number of neutrophils. The decrease in eosinophils and lymphocytes appeared to be mediated through the adrenal glands. The details of this study are available in other publications.[4,5] The conclusion was reached that fever, induced by microwaves, appeared to produce pituitary and adrenocortical stimulation.

PHYSIOLOGIC EFFECTS OF HEAT

The observed effects of microwaves do not seem to be differentiated from heating effects. Apparently, experimental data on nonthermal biologic effects of micro-

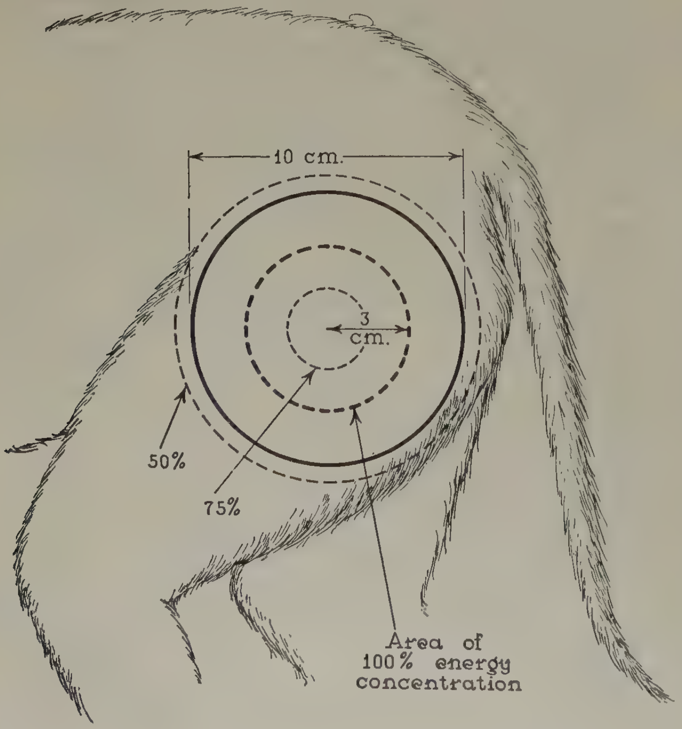

Figure 2 (left). The surface heat pattern of director A superposed on the thigh of the dog when the distance between the director and skin is 2.5 centimeters

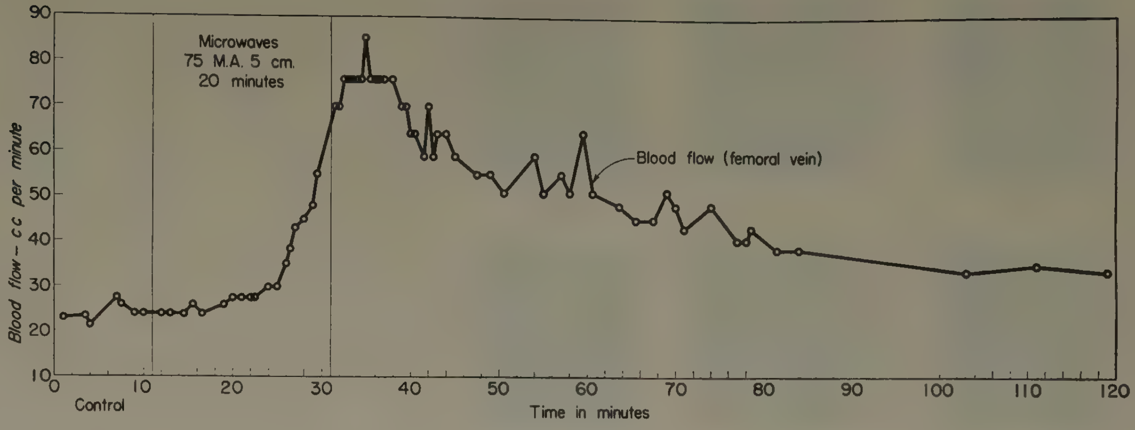

Figure 3. Blood flow in the thigh of the dog before, during, and after exposure to microwaves

waves have not been obtained. Since heating appears to be the primary effect of microwaves, it is well to review the physiologic effects of heat. Many research papers have been published on this subject. High body temperatures may cause denaturation of protein, irreversible coagulation of protein, increased permeability of cell membranes, liberation of toxins, and decrease in enzyme activity as well as many other changes. Chemical reactions in the body, just as in the test tube, are speeded up by rise in temperature and are slowed down by decrease in temperature. The rate of chemical reactions may be doubled by a rise of 10 degrees centigrade.

Obviously, the temperatures at which undesirable irreversible changes in bodily processes take place must be avoided. What are these temperatures? The healthy body may tolerate high temperatures for brief periods without serious aftereffects, but the very sick patient may be unable to tolerate temperatures considered safe for the so-called normal person. Actually the answer to the question is not simple even in the test tube where the complicated and compensating mechanisms of the living organism are absent. For example, consider a simple direct question such as, "At what temperature does protein coagulate?" An answer found in a textbook of comparative physiology[6] is as follows: "The coagulation temperature of a given protein may vary within wide limits, conditioned by the salt content of the solution, or even more by the hydrogen-ion concentration of the solution. For example, a 1-per-cent solution of crystallized egg albumen at pH 4.8 precipitates (forms coagulum) at about 60 degrees centigrade, while at pH 4.39 the coagulation forms

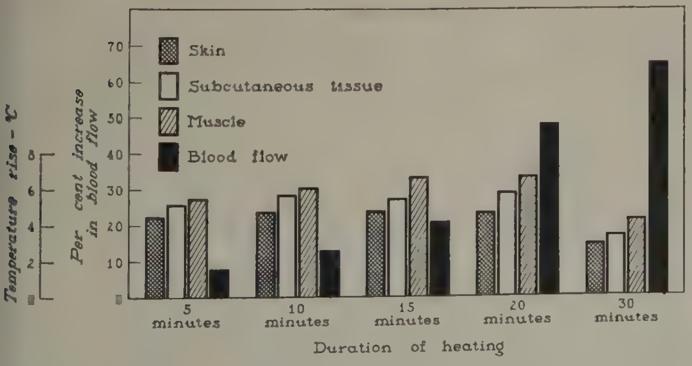

Figure 5. Effects of exposure to microwaves (80 watts) on blood flow and on temperature rises in human extremities

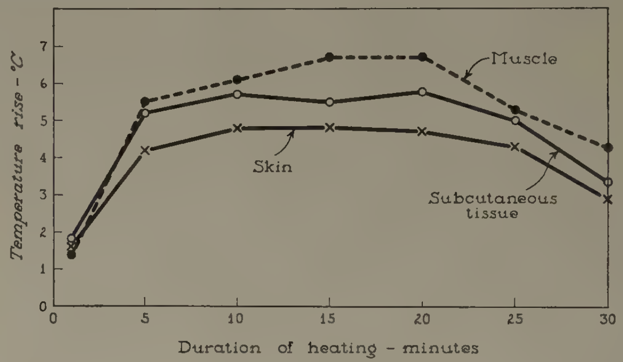

Figure 4. Temperature rise in various tissues of human extremities due to different periods of exposure to microwaves (80 watts). Temperatures were recorded 1 minute after turning off the microwave generator. Each point on the curves is the average of 10 to 26 observations

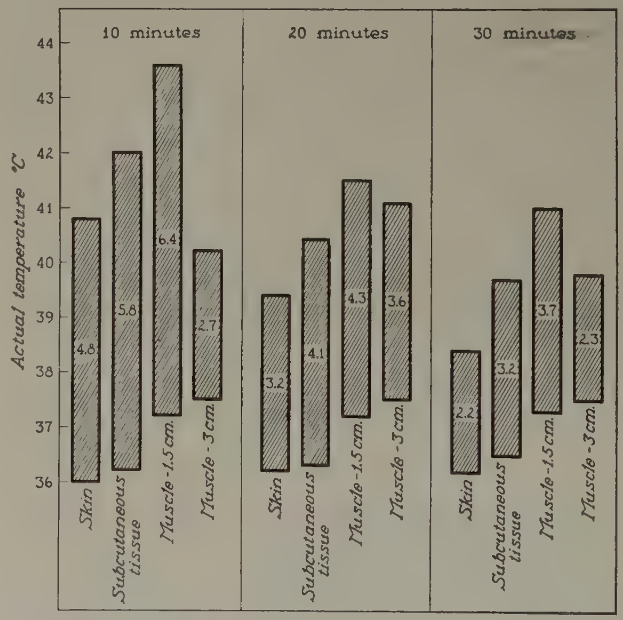

Figure 6. Changes in temperature in various tissues of the dog's thigh following microwave diathermy for 10, 20, and 30 minutes when using director C. Numbers in the center of the columns indicate temperature rises in degrees centigrade. The bases of the columns represent average control temperature before heating. The tops of the columns represent the final average temperatures. It should be noted that temperatures are maximal (except for muscle at 3 centimeters) at the end of the 10-minute period

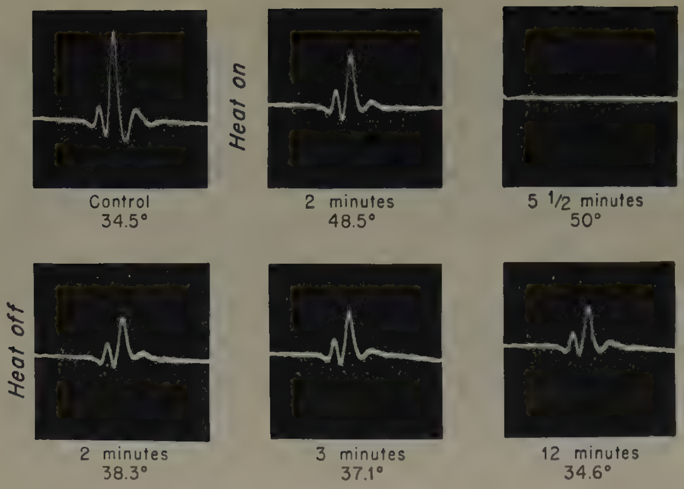

Figure 7. Changes in action potential in the sciatic nerve of the dog following application of heat

at about 80 degrees centigrade. At pH 4.25 or below, heat coagulation no longer occurs at 95 degrees centigrade, the solution becoming opalescent...."

One of the most striking characteristics of the human body is the relative constancy of its temperature under a variety of conditions. All warm-blooded animals maintain a fairly constant body temperature. Such a temperature is one of the most important factors in maintaining a normal pattern of biochemical reactions. Any significant deviation from this relatively constant temperature causes the very sensitive temperature regulatory mechanisms to become active. The neuron (the basic functional unit in the nervous system) is seriously impaired at high temperatures. At a temperature of about 41 degrees centigrade (normal temperature is 37 degrees centigrade) the central nervous system cannot function normally. Conditions such as prostration, coma, and even death may occur. It was found that the conductivity of the dog's sciatic nerve as indicated by its action potential can be abolished by heating the nerve directly, see Figure 7.

The circulatory system may be impaired seriously when body temperatures are high for prolonged periods. The vascular bed is increased. However, the circulating blood volume and the venous return may not increase proportionately with the result that the cardiac output may be decreased. To keep a normal blood pressure under these conditions the blood vessels constrict. Finally the constrictor mechanism fails and circulatory collapse ensues.

EFFECTS OF MICROWAVES ON ISCHEMIC TISSUES

PREVIOUS STUDIES HAVE DEMONSTRATED CLEARLY that relatively high temperatures in certain living tissues may be accompanied by increases in the flow of blood to these tissues. This increase in circulating blood brings about a decrease in the temperatures. Thus a mechanism for preventing the development of temperatures which may be too high is demonstrated. Suppose the circulatory system were so impaired that the blood flow to the given region exposed to microwaves could not increase. Experimentally such a situation can be simulated by placing a clamp on the main blood vessel which supplies blood to the given region thereby rendering the tissues ischemic. The effects of microwaves on tissues of the thighs of dogs were studied before and after clamping the aorta.[7] When using director *A* and a given output of microwave energy, no significant change was observed in the temperatures produced in ischemic tissues from those produced in tissues having the normal flow of blood as long as the periods of exposure to microwaves were brief, that is, 5 or 10 minutes. When the duration of exposure of the ischemic tissues was increased to 15 and 20 minutes gross evidence of burning occurred at temperatures which were considered beneficial for therapy. Temperatures tolerated by normal tissues cannot be regarded as safe for ischemic tissues. Blebs were formed in these ischemic tissues over the bony prominences at the site of the maximal surface heating. Fluid accumulated in these blebs. The rise in temperature of the fluid in the blebs was compared with that of the surrounding tissue. After exposure of these blebs to microwaves the temperature of the fluid in the blebs was considerably higher than the temperature of the tissues immediately surrounding the blebs, see Figure 8. This was to be expected from the dielectric properties of the mediums concerned.[8] Ischemic tissues cooled much more slowly after exposure to microwaves than did tissues having an adequate circulation of blood, see Figure 9.

CATARACTS CAUSED BY MICROWAVES

THE MOST SERIOUS pathologic effect of microwaves which was observed is the development of cataracts. This effect was unexpected. As this investigation is considered of particular interest to engineers who are working with microwaves, this report will include considerable detail. An investigation of the effect of microwaves on the eyes of dogs had been conducted by a group at Northwestern University.[9] This group reported that microwaves produced no deleterious effects on the eye other than temporary increased redness of the conjunctiva following

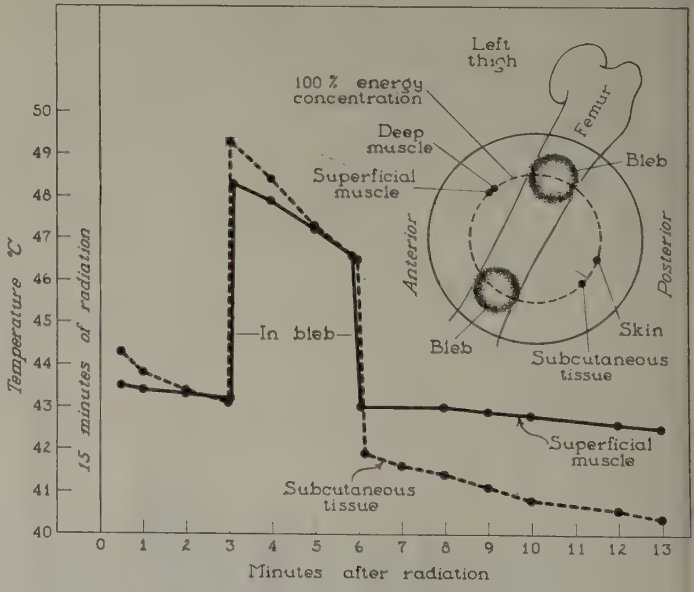

Figure 8. Temperature variations after microwave irradiation when blebs are present. The right upper corner shows the relationship of the surface heat pattern to the dog's femur. When burning occurred, the first evidence was over the femur at a site where the femur crossed the area of maximal heating

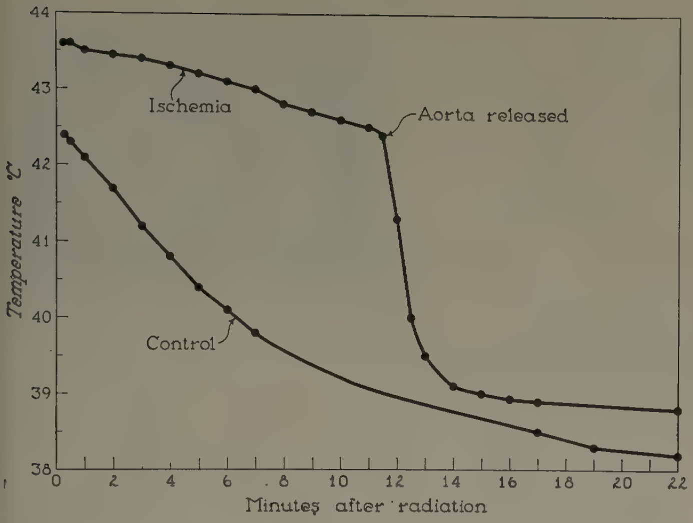

Figure 9. Comparison of cooling curves with and without ischemia, in deep muscle after 15 minutes of microwave diathermy. The rate of cooling of ischemic tissue was slower than normal even though the temperature was greater. Releasing the aorta resulted in rapid cooling of previously ischemic tissues

the exposure. The discovery of the production of cataracts in the research laboratory was made by a young ophthalmologist who had hoped to use microwaves for therapy in certain diseases of the eye.[10] Previously he had used short-wave diathermy with good results. As the microwave equipment seemed to be particularly well designed for applying heat to the eye, he wanted to study the possible therapeutic use of microwaves in ophthalmology. Director *C* was the most suitable for this purpose because the surface heat pattern is maximal at the center.

The investigations on the heating effects of microwaves on the eye began with a study of the temperatures produced in the vitreous humor, in the aqueous humor, and in the orbital tissues. Temperatures desirable for therapy could be developed and maintained. After the technical procedures necessary for obtaining optimal temperatures for therapeutic use had been established, another series of experiments was performed on eight dogs in which one eye was repeatedly exposed to microwaves, the other eye serving as a control. No temperature measurements were made in this series of experiments because it was desired to study the eyes clinically including opthalmoscopic examination of the media and fundi before and after exposure.

No clinically observable pathologic findings were encountered in the eyes of two dogs that were exposed once daily, six and ten times respectively, to an output of 75 watts at a distance of 3 inches (7.6 centimeters) for 30 minutes. An anterior cortical cataract was observed in one dog 6 days after the last of eight 30-minute daily exposures to an output of approximately 75 watts with the director 2 inches (5.1 centimeters) from the eye, see Figure 10. In another dog an anterior cortical cataract developed 24 hours after the last of seven 30-minute daily exposures during which the eye was at a distance of 1.5 inches (3.8 centimeters) from the director and the output of the generator was approximately 100 watts. These anterior cortical cataracts increased in size and density during the 9 succeeding weeks and then regressed whereupon posterior cortical cataracts appeared. Changes in addition to the cataracts were cell infiltration of the corneal stroma, vitreous opacities, reddening of the optic disk, and whitening and elevation of the retina in the region of the disk. Microscopic examination disclosed the presence of red blood cells, white blood cells, and fibrinous exudate in the anterior chamber with hemorrhage into the iris and ciliary processes.

When such pathologic effects occur it is well to extend the investigations to another species of experimental animal. The rabbit was the most suitable animal for further investigations on cataract formation. The same technical procedures as those used in studying dogs were employed. Two types of cataracts were observed in eyes of rabbits following exposure to microwaves. One type was seen only when grossly visible damage to other ocular structures was produced, namely, clouding of the cornea accompanied by congestion and hemorrhages into the iris and ciliary processes, see Figure 11. In this type the cataract appears immediately after exposure to microwaves and progresses rapidly until the entire lens becomes opaque.

The second type of cataract observed in rabbits does not appear immediately after exposure to microwaves. It becomes visible only after a time varying from several days to several weeks. This cataract is limited to the posterior cortex, but by repeated exposure to microwaves may be made to involve the entire lens, see Figure 12. Detailed papers describing the results of these investigations have been published.[11,12]

The development of microwave cataracts in the eyes of dogs and rabbits, confirmed independently and almost simultaneously by other investigators,[13] emphasizes the great importance of using particular caution whenever the exposure of eyes to microwaves is necessary. The results obtained by these other investigators have been published[14,15] for the primary purpose of calling to the attention of radio engineers the pathologic effects that may follow exposure of the eyes to microwaves. The need for caution in exposure of the human eye to microwaves is illustrated by the fact that in April 1952, at the Industrial Hygiene Conference in Cincinnati, Ohio, a report was given on bilateral lenticular opacities that had occurred in a technician who had been operating a microwave generator. The patient was a white man, 32 years old, who had slight myopia. The myopia made it necessary for him to work closer than usual to the antenna. One cannot be certain that the cataracts were owing to microwaves although there is strong evidence that the microwaves, 9- to 18- centimeter

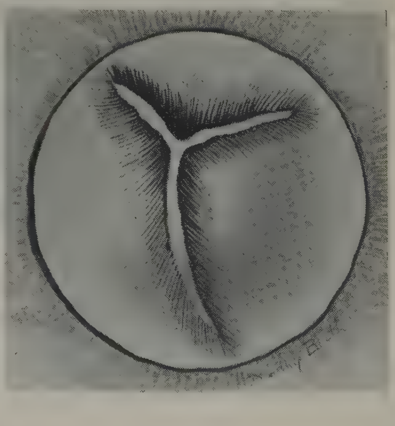

Figure 10. Drawing, as seen through the ophthalmoscope, of the anterior rosette cataract produced by repeated exposure of the eye of the dog to microwaves

wavelength, were responsible for the choroiditis and uveitis which preceded the development of cataracts.

It would be pleasing to be able to give engineers reliable data on field strength intensities for the threshold dose of cataract formation. Such data are difficult to obtain even by experts in the measurement of microwaves. In addition, a reliable statistical analysis of large numbers of data would be necessary to cover the ever-existing biologic variations in response to such radiations. Thus far only the conditions of exposure of eyes of the dog and the rabbit under which cataracts were not developed can be stated.

It also would be satisfying to be able to say that cataract formation takes place only when certain wavelengths are used. Unfortunately, these observations have been limited to one wavelength, namely, 12.2 centimeters (free space). However, other investigators [16,17] have studied changes in temperature of certain tissues due to electromagnetic radiations over a very wide range of wavelengths, namely, from 1,600 through 75, 12, 8, and 3 centimeters, and in the infrared region. According to Hirsch and Parker[18] wavelengths between 8 and 15 centimeters (free space) with outputs greater than 10 watts per square decimeter (continuous wave or average) are capable of causing the most tissue damage. Clark[15] stated that the wavelength of 10 centimeters (free space) proved to be the most dangerous to living organisms and that wavelengths between 6 and 12 centimeters (free space) are about equally effective in producing elevated temperatures in the body.

SUMMARY AND CONCLUSIONS

Investigations indicate that the primary physiologic effects of microwaves are owing to the heating caused by the microwaves. In certain tissues temperatures which are considered optimal for medical diathermy can be attained easily and maintained satisfactorily. An increase in the flow of blood through these tissues accompanies the increase in temperature. Thus electromagnetic energy in the microwave range is an excellent agent for use in therapy.

When the heating by microwaves is general and fever, hyperthermia, was induced in the rat, a marked decrease in the number of eosinophils and lymphocytes and a marked increase in neutrophils occurred. These changes appeared to be mediated through the adrenal gland.

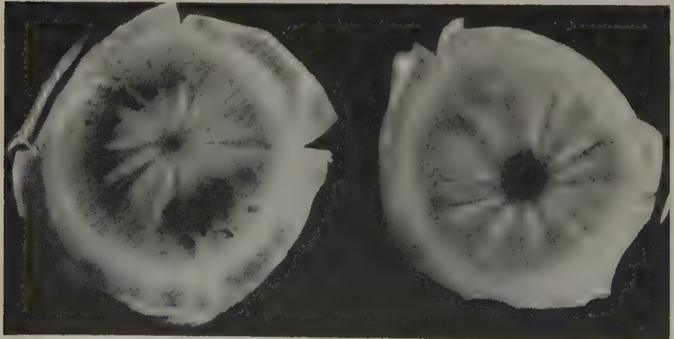

Figure 11. The posterior surface of the iris and ciliary region of the eye of an albino rabbit immediately after exposure to microwaves (left). The posterior surface of the iris and ciliary region of the unexposed (control) eye of the same rabbit (right). Hemorrhage and congestion in the exposed eye are evident

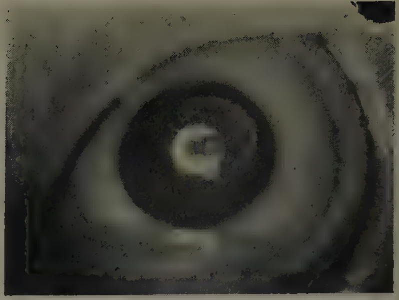

Figure 12. Circumscribed, posterior cortical cataract produced by exposure of the eye of a rabbit to microwaves

The formation of cataracts was the most serious pathologic effect of microwaves observed, but other undesirable effects on the eye took place.

Microwaves should be applied with particular caution to the eye, ischemic tissues, regions in which there are effusions, collections of fluid, or pronounced edema, regions in which there are tendencies to hemorrhage, and regions in which there are bony prominences.

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A Gain and Phase Angle Measuring Set

F. B. ANDERSON

THIS TRANSMISSION MEASURING SET has been found particularly useful in connection with the design of feedback amplifier circuits. A wide frequency range over which gain and phase can be directly read with sufficient accuracy for many design purposes has been achieved. The capabilities of the set are as follows:

1. Transmission magnitude: −18 to +68 decibels to ±1 decibel
2. Transmission phase shift: 0 to ±180 degrees to ±10 degrees
3. Frequency range: 10 cycles to 10 megacycles
4. Input voltage to unknown: 0.0003 to 3 volts peak
5. Output voltage from unknown: 0.38 to 0.76 volt peak
6. Generator impedance: 0 to 68 ohms
7. Probe impedance: 3 megohms, 10 micromicrofarads } paralleled

The accuracies quoted are nominal. The spread is larger at the extreme frequencies, smaller in midband. A wide frequency range has been achieved with fair accuracies and essentially single-knob control. Indications are continuous and directly read from two meters, plus a gain dial.

The measuring set, shown in simplified form in Figure 1, employs a sine-wave voltage of 3 volts peak. An adjustable attenuator brings the input to the unknown within the available 6-decibel range of operation. A 3-stage negative feedback amplifier provides a high impedance for picking up the output from the unknown. This amplifier drives a thermocouple meter through a coupling tube for interpolating gain or loss readings between the 5-decibel steps of the input attenuator. This amplifier also drives a single-stage balanced battery-biased varistor limiter. The clipped sine wave output from the limiter is fed to the grid of a phase-measuring tube. A similar "standard" amplifier bridged on the input to the set drives a second limiter, the output of which is coupled to the cathode of the phase-measuring tube. The plate current of this tube is proportional to the phase displacement of the grid and cathode voltage waves. The sign of the measured phase angle is determined by bridging a broadband phase shifter across the input to the standard side amplifier.

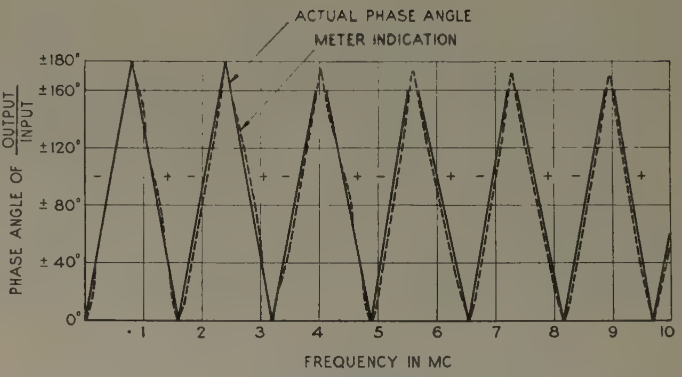

Figure 2. Phase meter measurement of 400 feet of 724 cable

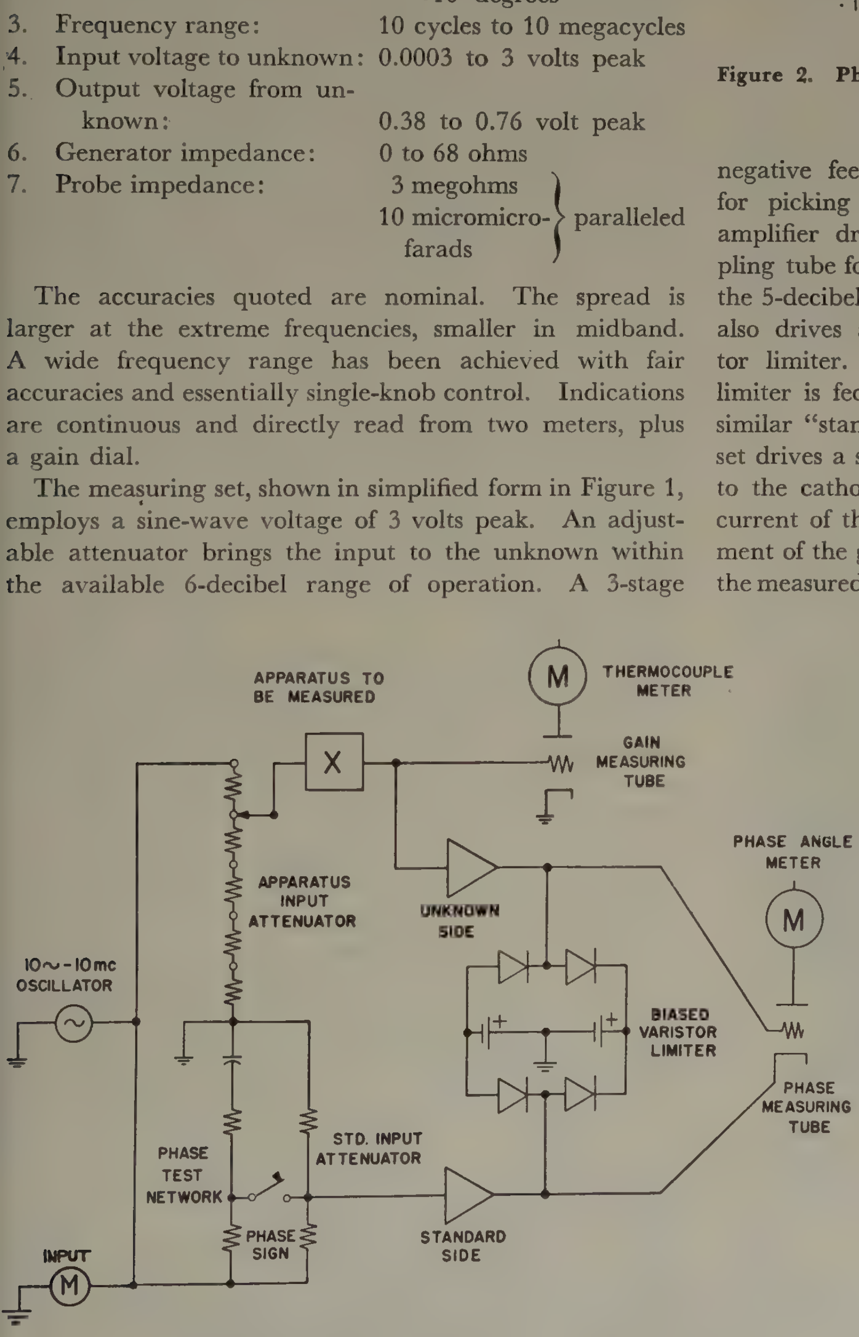

Figure 1. Functional schematic of the phase and gain angle meter

The accuracy provided is sufficient for the design and production of a stable negative feedback amplifier, in which phase angles between 0 and 45 degrees in the region of +10 to −10 decibels feedback are important. The measuring set is also useful in the rough evaluation of other networks, such as equalizers. It is very useful in covering continuously a wide frequency band. When very accurate measurements are required, it can usefully indicate the frequency ranges requiring detailed attention with more elaborate and perhaps unwieldy measuring systems. Figure 2 shows a typical performance.

Digest of paper 52-46, "A 10-Cycle to 10-Megacycle Gain and Phase Angle Measuring Set," recommended by the Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Not scheduled for publication in AIEE *Transactions*.

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Permanent-Magnet Fields for Synchronous Machines—I

M. W. BRAINARD
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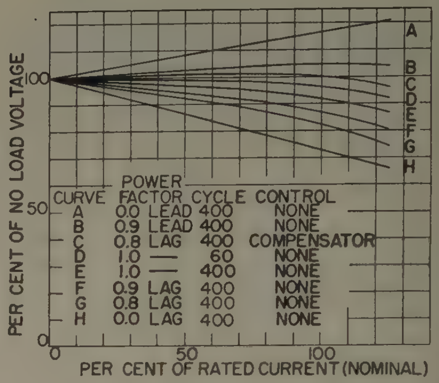
PERMANENT-MAGNET generators have been built with ratings ranging from a few watts up to many kilowatts. Figure 1 shows a 0.1-kw rotor suspended from a 75-kva unit and even larger capacities and higher speeds are possible. The armature of permanent magnet alternators may be of conventional design, but the field structure is inherently different and in the last 6 years a rotor structure has been developed which is sound mechanically, efficient magnetically, and simple to manufacture.

Figure 3. Voltage versus load characteristics of typical permanent magnet generators with various power factor loads both with and without a compensator



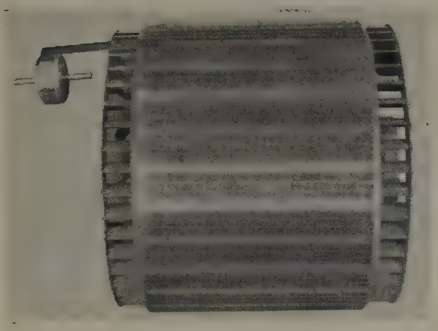


Figure 1. 75-kva 28-pole 1,714-rpm 400-cycle rotor, single-bearing construction arranged for direct connection. The 0.1-kw 12,000-rpm rotor is shown suspended by magnetism alone from a 6-inch steel scale

The latest designs have laminated pole shoes and inner magnet ties locating rectangular blocks of Alnico *V* in exact alignment between annular disks of nonmagnetic steel, all cast centrifugally with an aluminum alloy. Figure 2 shows a 4-pole rotor partially assembled. The extended pole tips shown provide the necessary magnetic leakage; and, when cast, the aluminum surrounding each pole supplies sufficient damping action to prevent excessive demagnetization from sudden short circuit.

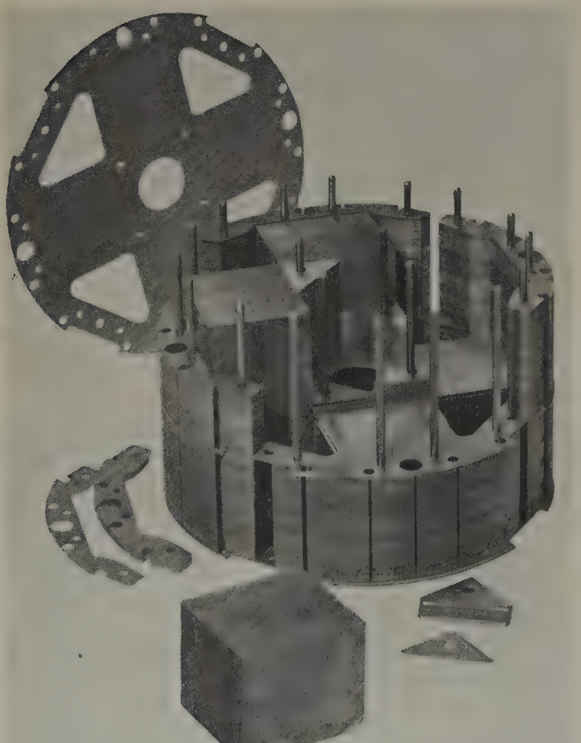


Figure 2. 6.3-kva 4-pole 60-cycle rotor magnet assembly, partially stacked, showing special high leakage extension to the pole tips and the loosely supported inner magnet ties. The main shaft is installed in this assembly after casting

Permanent-magnet alternators inherently are smaller, lighter, and more efficient than conventional machines complete with exciters, and they have no more radio interference or maintenance problems than a simple squirrel-cage induction motor which they closely resemble. The cost of the larger rotors is appreciable due to the present high price of the Alnico *V* magnets, but the other advantages outweigh the cost factor for a great many applications.

Voltage regulation and control is still a problem requiring considerable development although much progress has been made. A special winding on the stator can be used to superpose a direct field on the stator alternating field to obtain a small range of effective and accurate voltage control; and a series transformer-capacitor device, called a compensator, is very effective in correcting for low power factor loads. The inherent voltage regulation is similar to a highly saturated electromagnet machine and typical curves are given in Figure 3.

Design of permanent-magnet generators is based upon the demagnetizing characteristic of the magnet material and it is complicated by requirements of no voltage change following disassembly or short circuit as well as the economic necessity of obtaining the required output from a minimum amount of magnet material. In many cases the limiting factor is the difficulty of magnetizing the entire length of the magnet to near full saturation.

Digest of paper 52-224, "Synchronous Machines With Rotating Permanent-Magnet Fields—Part I. Characteristics and Mechanical Construction," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in the AIEE *Transactions*, volume 71, 1952.

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Permanent-Magnet Fields for Synchronous Machines—II

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MOST OF THE PROCEDURES and formulas for the electrical design calculations of synchronous machines with electromagnetic field poles may be adapted also to machines with permanent-magnet fields, but without quite the same close degree of conformity between prediction and actual performance. The main reasons for this discrepancy are: magnetic tolerances in the hard magnetic material, assumptions in practical leakage calculations, uncertainty in locating exactly the position of the minor hysteresis loop when the magnets have been stabilized by short circuit, and difficulties in magnetizing closely spaced poles to full saturation.

Design of a magnetic circuit containing permanent magnets must be based on the calculation of the leakage flux. The method of "estimating permeances of probable flux paths"[1] seems to be most convenient for the derivation of practical formulas and curves. The point of magnetic stabilization, B_{st}, which is determined by the intersection of the out-stator leakage line with the demagnetization curve, yields the air-gap flux density seen in Figure 1. These curves were calculated for a typical machine at different demagnetizing forces, H_d, in the direct axis.

In a well-designed machine, B_{st} must be chosen below the point of maximum energy on the demagnetizing curve, that is, below about 63 kilomaxwells per square inch for Alnico V. . The lower limit will be about 40 kilomaxwells per square inch, dependent on the value of H_d corresponding to the armature reaction at rated load. This requirement can be met easily for machines with eight or more poles. Machines with six poles or less generally have low pole leakage and the magnets may be stabilized too far below the optimum point. Special shapes of the laminated pole shoes or the selection of more coercive magnetic material, Alnico VI or XII for example, may increase the voltage output and improve the inherent regulation. Larger machines generally are air stabilized but it may be advantageous to stabilize small machines, particularly those with reduced service lifetime, in the stator by short circuit or in removable keepers.

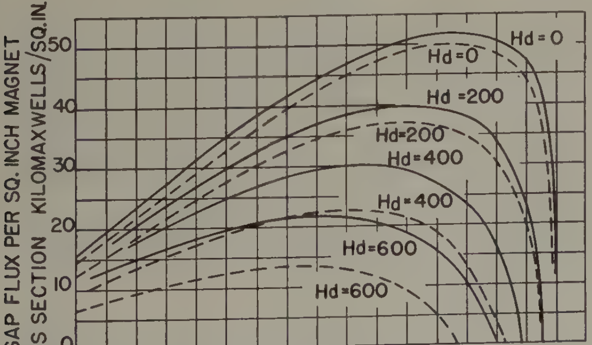

Figure 1. Relation between air-gap flux densities in Alnico V for different demagnetizing forces of the armature reaction. The solid lines are for air stabilization, the dashed lines for stabilization by ideal short circuit

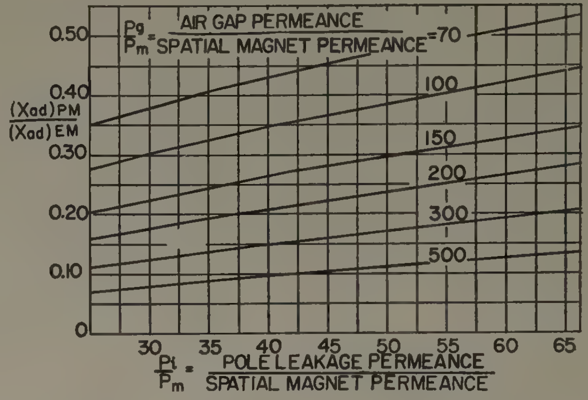

Figure 2. Ratio of reactances of direct-axis armature reaction in synchronous machines with permanent magnet poles to those of machines with electromagnetic poles

Due to the low permeability of the hard magnetic material, the reactance of the direct-axis armature reaction is smaller than in electromagnetic machines as can be seen from Figure 2, where $(X_{ad})_{em}$ is the conventionally calculated reactance. The reactance of the quadrature-axis armature reaction (X_{aq}) will be the same as in electromagnetic machines provided the soft iron pole shoes are shaped conventionally. The ratio X_{ad}/X_{aq} for permanent-magnet machines will be generally <1. This is contrary to the relations in electromagnetic machines where the ratio is usually >1.

Obviously, the short-circuit ratio, scr, of a permanent-magnet machine cannot be defined by the definition given in the "American Standard Definitions of Electrical Terms," which is based on the ratio of field currents. The scr for permanent-magnet machines must be based on the ratio of air-gap flux density and demagnetizing ampere-turns as well as the permeances of the magnetic circuit.

The air gap can be chosen as small as is practical mechanically because of the reduced armature flux in the direct axis. A concentric air gap has proved itself to be most appropriate both electrically and mechanically.

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Design Chart for a Single-Layer Air-Core Transformer

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The development of radar and television has caused considerable use of wide-band amplifiers which often employ transformer coupling. In many of these applications, the single-layer configuration with no space between windings is practicable. To eliminate trial and error in the design of these transformers this chart has been prepared.

TO DESIGN air-core transformers of the type shown in Figure 1, the design chart, Figure 2, is useful. The primary and secondary each consist of a single-layer solenoid on the same axis and having the same pitch and diameter. There is no space between the primary and secondary. Figure 2 also applies to a tapped solenoid.

Wide-band amplifiers frequently use transformer coupling with relatively large mutual inductance. In many of these cases, the single-layer configuration with no space between the windings provides a practical design. Other applications include receiver input and output coupling circuits, and oscillator tank coils.

A tapped coil, or its 4-terminal equivalent, is not completely specified by the total inductance and the position of the tap; for example, the coupling coefficient between sections decreases as the length-to-diameter ratio of the coil increases.

Given the geometry of such a coil, it is easy to determine the inductances L_1 and L_2 and the mutual inductance M. The design problem, however, is the inverse of this: given L_1, L_2, and M, determine the geometry of the coil. In order that such coils may be designed without trial and error, Figure 2 has been prepared.

The following example will illustrate the method of using this chart:

Required: a transformer or tapped coil having L_1, the inductance of the smaller coil = 10 microhenrys.

Let L_2, the inductance of the larger coil = 20 microhenrys, and the coefficient of coupling, $k = 0.177$.

1. Apply the usual formula, $M = k\sqrt{L_1L_2}$, and find that $M = 2.5$ microhenrys.

2. Calculate the inductance L_T of the entire coil-connected series aiding, from the formula $L_T = L_1 + L_2 + 2M$. L_T is found to be 35 microhenrys.

3. Calculate L_1/L_T and L_2/L_T: they are found to be 0.286 and 0.571 in the example given.

4. The curved lines on the chart represent values of L_1/L_T and L_2/L_T: find the point having the correct values of these two parameters.

5. Read l/D for the entire coil from the base of the chart, and α, which is the proportion of the length of the entire transformer which is occupied by the smaller coil, from the ordinate. In the example given $l/D = 2.14$, and $\alpha = 0.371$.

6. The entire coil is now designed by any method[1,2] which uses the parameter l/D. The location of the tap or break between windings L_1 and L_2 is given by the value of α. In the example given, let us choose a 1-inch coil. (Note that for best accuracy D is not the diameter of the form, but rather the diameter of the coil measured to the center of the wire.) Then the length of the coil must be 2.14 inches to make $l/D = 2.14$. The chart of reference 1 shows that to obtain an inductance of 35 microhenrys, the total number of turns, N, must be 60. Since $\alpha = 0.371$, the number of turns in the smaller coil is αN which equals 22.2.

If the l/D ratio is found to be impractically large, giving a long thin coil, then "fatter" coils using a space between primary and secondary may be used. Conversely, if l/D is found to be too small, the desired coil cannot be constructed in this form.

The use of a shield-can will lower the primary and secondary inductance by a known amount.[3] No references have been found for the effect of a shield-can on mutual inductance. Rough experiments with various shield-cans on a typical coil ($l/D = 0.80$, $\alpha = 0.31$) have indicated that for this coil the reduction in mutual inductance is about 2.3 times as great as the reduction in self-inductance of the larger coil. With a shield diameter of three times the coil diameter, the mutual inductance was reduced 6.5 per cent by the shield.

The formulas used in preparing the chart were Nagaoka's formula,[2] Wheeler's approximation to this formula, and the formula $L_T = L_1 + L_2 + 2M$.

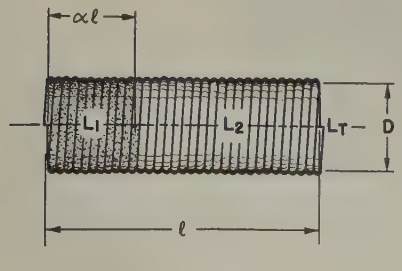

Figure 1. Type of air-core transformer to which the design chart, shown on opposite page, is applicable. L_T = total inductance when connected aiding ($L_T = L_1 + L_2 + 2M$), where M = mutual inductance

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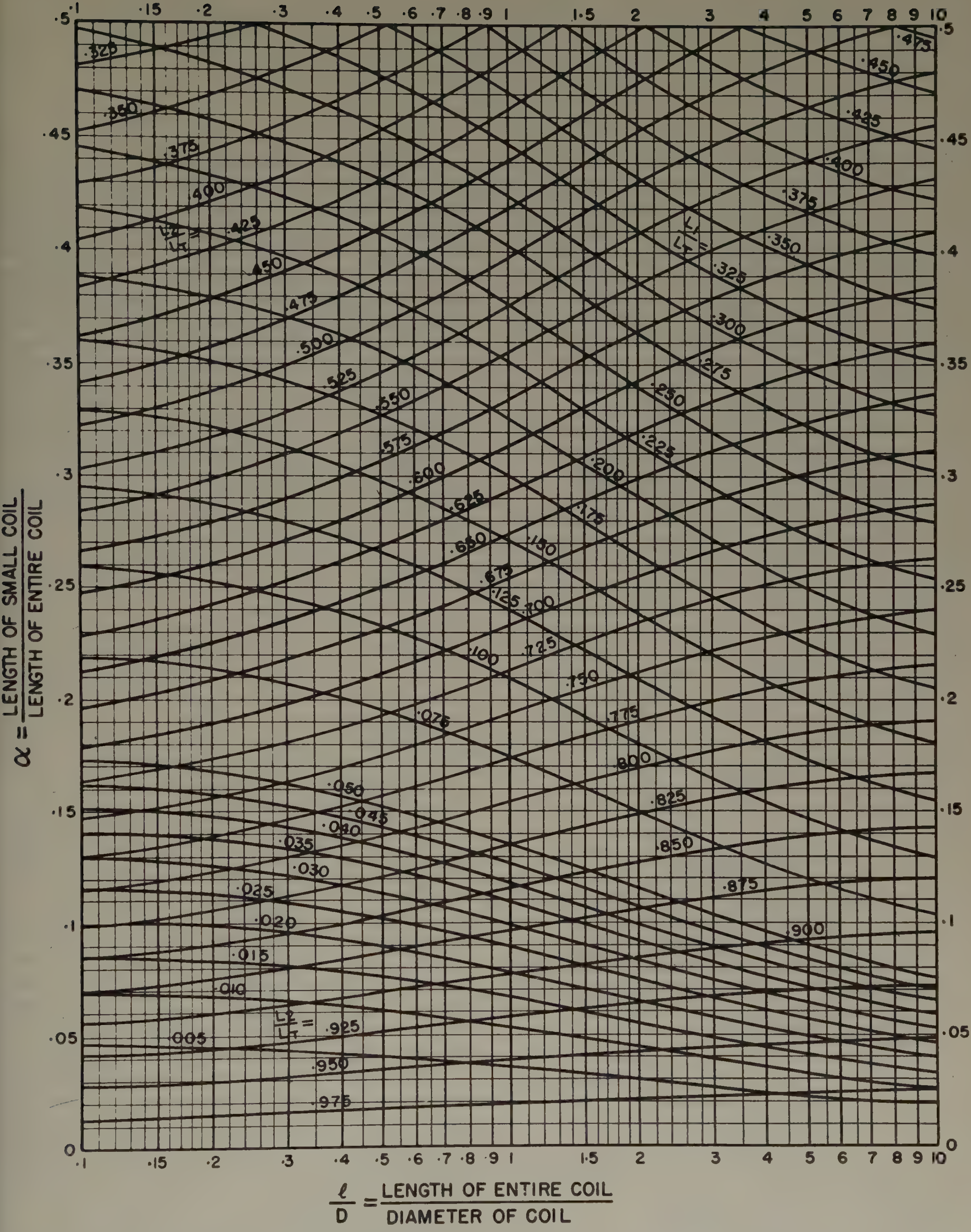

Figure 2. Design chart for single-layer air-core transformer

A New Type of Magnetic Servo Amplifier

W. A. GEYGER
MEMBER AIEE

IN REFERRING to the damping properties of 2-phase induction motors which are extensively used in high-performance servomechanisms, it is important to stress that some of these motors have good viscous friction to inertia ratios or special damping means, and others have not. Separately excited induction-meter-type reversible motors, as sometimes used in self-balancing potentiometer recorders, have a permanent magnet producing eddy-current damping. Some types of low-inertia squirrel-cage induction motors and drag-cup-type motors have eddy-current damping devices built into the motor. There are, however, other constructions of such motors which have virtually no damping properties so that additional damping methods must be applied to prevent hunting.

The use of vacuum-tube amplification offers the possibility of introducing effective dynamic braking of the motor by means of the d-c component flowing through the plate circuit, which contains the amplifier field winding of the 2-phase induction motor. However, if such a motor is to be controlled by means of a magnetic servo amplifier, considerable practical difficulty will be caused by the fact that the alternating load current of the conventional magnetic amplifiers of the balance-detector type does not have a d-c component which may be used for producing dynamic braking of the motor.

Figure 1 shows a new 2-stage magnetic amplifier for high-performance servomechanisms, particularly to be used in connection with those types of 2-phase induction motors having such a low ratio of effective viscous friction to inertia that it is difficult to stabilize at high gain in a closed loop. The basic idea consists in feeding the amplifier field winding of the a-c reversible motor by a variable unidirectional current having a fundamental frequency (60- or 400-cycle) component and a d-c component producing an effective dynamic braking of the motor, preferably in such a way that the d-c component increases when the a-c component decreases, and conversely. The output-stage circuit of the magnetic servo amplifier, Figure 1, contains:

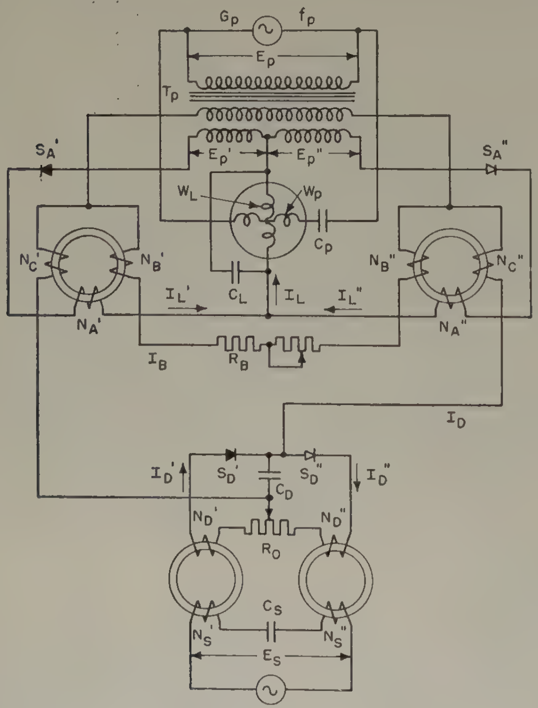

Figure 1. **New type of full-wave 2-stage magnetic servo amplifier circuit having dynamic braking properties**

1. A center-tapped power supply transformer T_P providing two equal voltages E_P', E_P'' which are proportional to the power supply voltage E_P (frequency f_P).
2. The load windings N_A', N_A'' of two saturable reactor elements, preferably having Orthonol tape cores.
3. Two series-connected half-wave selenium rectifier sets S_A', S_A'' producing self-saturating effects.
4. A-c bias windings N_B', N_B'' with resistor R_B.
5. D-c control windings N_C', N_C'' which are supplied from the input-stage circuit.
6. The amplifier field winding W_L of the 2-phase reversible induction motor with shunt capacitor C_L.
7. The line field winding W_P with capacitor C_P.

The various purposes of the input-stage circuit are

1. To act as a push-pull-type magnetic amplifier to produce variable control current I_D, a function of the reversible error voltage E_S.
2. To act as a phase discriminator (in a way similar to a phase-sensitive rectifier) so that actual direction of the resultant output current component $I_D = I_D' - I_D''$ will correspond to the actual phase displacement between error voltage E_S and power supply voltage E_P.
3. To act as a voltage-sensitive bias element to the output-stage circuit for introducing special characteristics.
4. To act as a decoupling device in such a way that no appreciable alternating voltage will be induced in the synchro-transformer a-c control circuit having a total impedance of about 10,000 ohms.

Proper phase relationship of the currents flowing through the various parts of this 2-stage circuit and maximum torque conditions of the 2-phase motor will be obtained by means of the capacitors C_P, C_L, C_D, and C_S. It is to be noted that actual values of output-stage quiescent currents I_L', I_L'' and the corresponding intensity of the dynamic braking effect can be controlled easily by adjusting the variable bias resistor R_B.

Digest of paper 52-237, "A New Type of Magnetic Servo Amplifier," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in the AIEE *Transactions*, volume 71, 1952.

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Ice-Melting Practices on Transmission Lines

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THE SHORT-CIRCUIT and phase-shift methods for removal of ice formation from approximately 95 per cent of its 3,200 miles of 33-, 66-, and 132-kv transmission lines are being used by Public Service Company of Northern Illinois, Wheaton. These methods are used when the severity and extent of ice storms in the company's 11,000 square miles of territory make ice prevention measures through additional line loadings and current circulation in transmission-line loops not wholly effective.

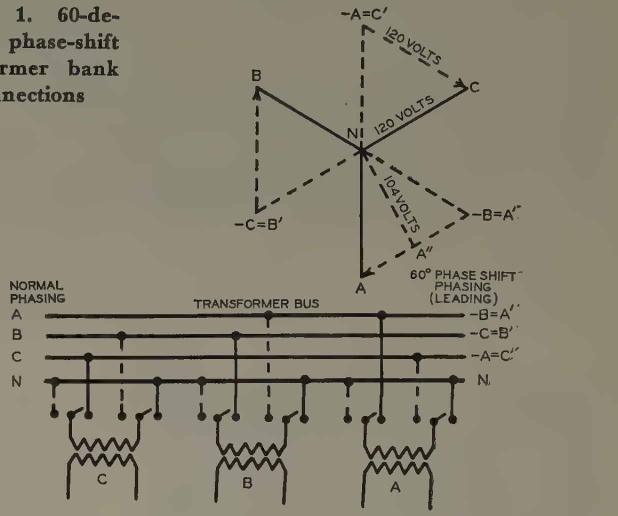
Both methods are directed toward the use of high-current values to shorten the length of the ice-melting operation. Time-current curves for various size conductors under various conditions of wind velocity and ambient temperature are used as a guide for these operations and switching routines are prepared in advance. As the magnitude of power requirements is high, it is essential that melting centers be backed up with a firm source such as the 66- and 132-kv transmission systems. The lines of these systems therefore receive first attention when melting operations are required. Sufficient transformer capacity must be available to carry both the melting and normal load current simultaneously.

The short-circuit method used by Public Service Company since 1923 consists essentially of short-circuiting or grounding one end of a line or line combination, and applying a melting current from the station bus at the other end.[1] To expedite the operation, permanent ice-melting busses, disconnects, and cables have been installed at substations in recent years. Line short-circuiting switches also have been installed on some lines to eliminate the connection of temporary jumpers. Some of these are of the load-interrupter type of 600-ampere capacity capable of applying and removing short circuits on energized 33-kv lines. Use of this type of switch eliminates the necessity of interrupting service to customers while the line is being prepared for current application.

To expedite the ice-melting operation further, the phase-shift or out-of-phase method is used in many cases. Essentially this method consists of changing the connections on a transformer bank by means of disconnects to create a phase-angle difference between it and other standard-connected transformer banks. Circulating current of sufficient magnitude to melt ice then can be caused to flow over a transmission line connecting the standard bank and the phase-shifted bank. The amount of circulating current will depend on the voltage impressed on the line, its impedance, and the degree of phase shift.

A transformer bank can be adapted readily for this method by installation of six single-blade double-throw disconnects on the secondary leads from the transformers. Figure 1 shows how a transformer bank can be reconnected for a 60-degree phase shift by means of these disconnects. Disconnects operated in one position give normal phasing. When closed to the opposite position, a 60-degree phase displacement is created with respect to other standard-connected transformer banks. The out-of-phase voltage impressed on a transmission line connecting a 60-degree phase-shifted bank and a standard bank which will cause circulating current to flow is equal to the phase to neutral secondary voltage of the transformer bank and is represented as AA', BB', and CC' in Figure 1. The minimum voltage between the two ends of the transmission lines shown as NA'' equals 87 per cent of normal voltage.

Figure 1. 60-degree phase-shift transformer bank connections



Use of the 60-degree phase-shift method on 33-kv lines from which customers are supplied has two very important advantages over the short-circuit method. The first is that service to customers need not be interrupted at any time. The second advantage in the use of this method is the considerable reduction in the amount of preparatory line switching required, reducing the elapsed time for removing ice, and permitting a wider coverage of melting operations before a drop in ambient temperature and increased wind velocities make such operations more difficult. The phase-shift method unfolds numerous possibilities for application to line combinations of like voltage as well as to line combinations of unlike voltages.

The 120- or 180-degree phase shift is also used to melt ice from some 132-kv lines using 33-kv potential. These displacements are obtained by means of permanently installed disconnects and cables on transformer-bank connections. Ice-melting current can be caused to flow over a 132-kv line when one end is connected to such a transformer bank and the other connected to a 33-kv bus supplied from a standard-connected transformer bank.

Digest of paper 52-186, "Ice Melting and Prevention Practices on Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

V. L. Davies and **L. C. St. Pierre** are both with the Public Service Company of Northern Illinois, Wheaton, Ill.

The Combustion Gas Turbine and Its Applications

B. G. HATCH
ASSOCIATE MEMBER AIEE

Several gas turbines have been placed in commercial operation within the last few years as prime movers. Their operating records indicate their use should be considered when economic studies are being made for various applications. Several possible applications are suggested.

WITH SOME 3 YEARS' OPERATING experience on the first commercially successful combustion gas turbines in central station and locomotive service, it is time to reconsider possible applications for these new prime movers. By way of introduction, the various ratings and cycles now in production by the General Electric Company will be reviewed briefly.

THE SIMPLE-CYCLE GAS TURBINE

THE 4,800-HORSEPOWER SIMPLE-CYCLE-TYPE GAS turbine, see Figure 1, for use in a locomotive was first announced in June 1947,[1] and in November of 1948 was first operated in a locomotive cab in Erie. In July of 1949, this locomotive started 2 years of regular service on the Union Pacific Railroad, and operated 6,500 hours and 115,000 miles. A duplicate unit rated 3,500 kw was also installed in July of 1949 at the Belle Isle station of the Oklahoma Gas and Electric Company, see Figure 2, for operation on natural gas.[2] This unit now has over 26,000 hours of essentially continuous base load central station service, at an average load 20 per cent in excess of rating, with no major repairs or replacements.[3,4] Another duplicate 3,500-kw unit was installed by the Central Maine Power Company in 1950, and another unit has been added by the Oklahoma Gas and Electric Company.

This simple-cycle gas turbine is now in regular factory production, and the first of ten production model gas turbine-electric locomotives went into regular freight service January 28, 1952.

THE COMPOUND AND REGENERATIVE CYCLE

IN 1948, a 5,000-kw compound-cycle gas turbine for power generation and central station service was announced, see Figure 3. To obtain better fuel rates this new design incorporates water-cooled intercoolers, between two stages of compression, and regenerators partially to recover waste heat from the exhaust.

Three units of this new design went into operation in October 1950, and June and August of 1951 in new stations of the Bangor Hydro Electric Company,[5] see Figure 4, Public Service Company of Oklahoma, and Central Vermont Public Service Corporation. These units now have operating records from something over 1,000 hours in daily peak load service to over 8,200 hours in regular system operation.

It was early recognized that the gas turbine is very well suited to long-distance natural-gas pipe-line pumping. Therefore, several years ago, a third design was started for a turbine having variable-speed–variable-load characteristics suitable for operating a 5,000-horsepower centrifugal compressor. In November 1951, announcement was made of this new 5,000-horsepower regenerative-cycle design gas turbine which incorporated an independent load turbine, mounted in the same casing with the high-pressure turbine which drives the main air compressor,[6] see Figure 5. The first turbine of this new design was shipped to the Texas Power and Light Company in December of 1951, see Figure 6, to drive a 4,000-kw generator in central station service. Several duplicate units have since been shipped to the El Paso Natural Gas Company to drive 5,000-horsepower centrifugal gas compressors for their new 800-mile high-pressure line from Texas to California.[7]

APPLICATIONS FOR POWER GENERATION

IT IS OBVIOUS THAT THE GAS TURBINE has found a place in the field of power generation. The present ratings of 3,500 kw and 5,000 kw have many possible applications which should be carefully considered:

1. Base load plants. Where an increment of 3,500 or 5,000 kw is of real importance on a system, the gas turbine has many obvious advantages.

2. Peak load plants. An outstanding advantage of the gas turbine is the ability to start and be ready for full loads in a matter of 15 to 30 minutes. At the end of a run, there are no stand-by losses.

3. Stand-by service. The quick starting characteristics and absence of stand-by losses of the gas turbine may be used advantageously to firm up system power during times of adverse conditions or outages.

4. End-of-line plants, or new load territory. An end-of-line gas turbine will firm up the load in case of line outage from storm or catastrophe, and will reduce system losses and stabilize voltage and service during local peaks, or as the load grows.

District paper presented at the AIEE South West District Meeting, St. Louis, Mo., April 14–17, 1952.

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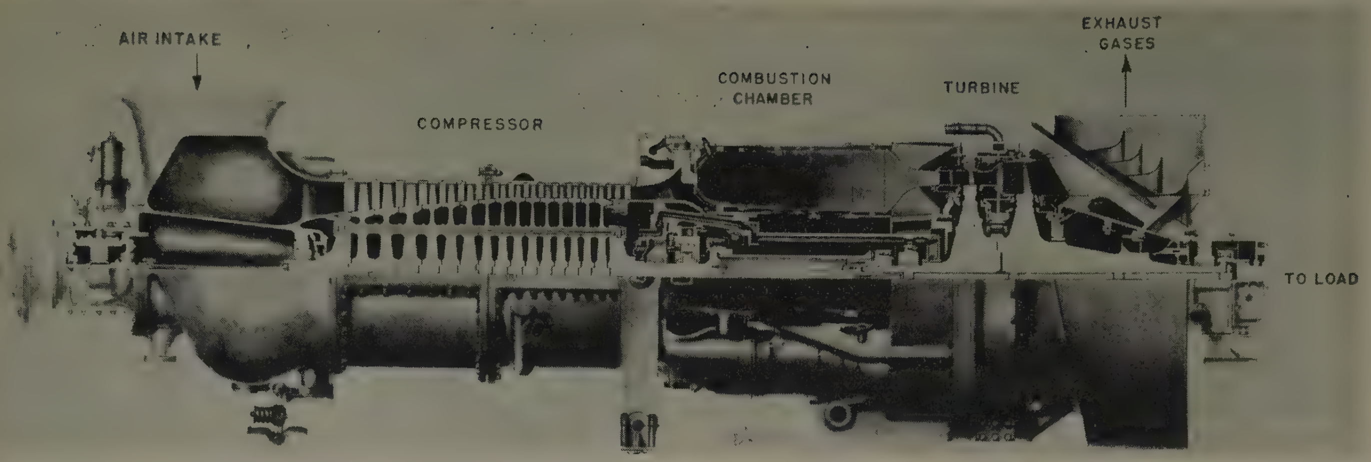


Figure 1. Cross section of 4,800-horsepower simple-cycle locomotive-type gas turbine

5. Improve station heat rate, or heat balance. Where there is a requirement for quantities of low-pressure steam, or for heating boiler feed water as at Oklahoma City or for topping small low-pressure steam turbines up to 250 pounds, the gas turbine used with an exhaust heat recovery boiler will develop up to 10 or 12 pounds of steam per kilowatt-hour, with little additional expenditure of fuel.

6. Requirement for power where water is scarce or costly. The gas turbine requires only a small quantity of cooling water necessitating very little make-up.

Any or all of the foregoing suggested uses should be given full consideration where an increase in generation within the scope of the gas turbine is required.

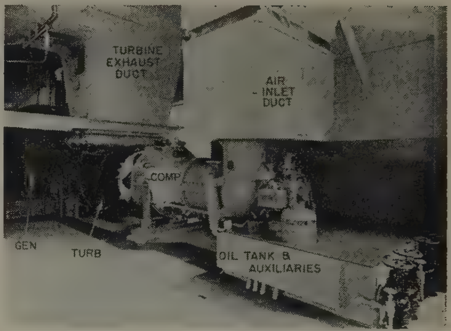
INDUSTRIAL POWER GENERATION

MANY MANUFACTURING PLANTS find it necessary to generate part or all of their own power, for a number of reasons. These may include:

1. Requirement of process steam for manufacturing purposes. The ability of the gas turbine to generate steam at low cost with a waste heat boiler is particularly attractive.

2. Expansion beyond capacity of the local equipment to serve adequately. Installation of the gas turbine may permit taking part or all of the new expansion, or of the peak loads, with the base load carried by present facilities.

Figure 2. First 3,500-kw simple-cycle gas turbine-generator unit installed in Belle Isle station, Oklahoma Gas and Electric Company



3. Stand-by for present facilities. Where continuous manufacturing processes are involved and a shutdown would be costly, a gas turbine may serve as a backup in case of interruption, or during planned maintenance on other power supply equipment.

For those industries who find it necessary to generate their own power because of need for process steam, or in parallel with purchased power, or because of other special

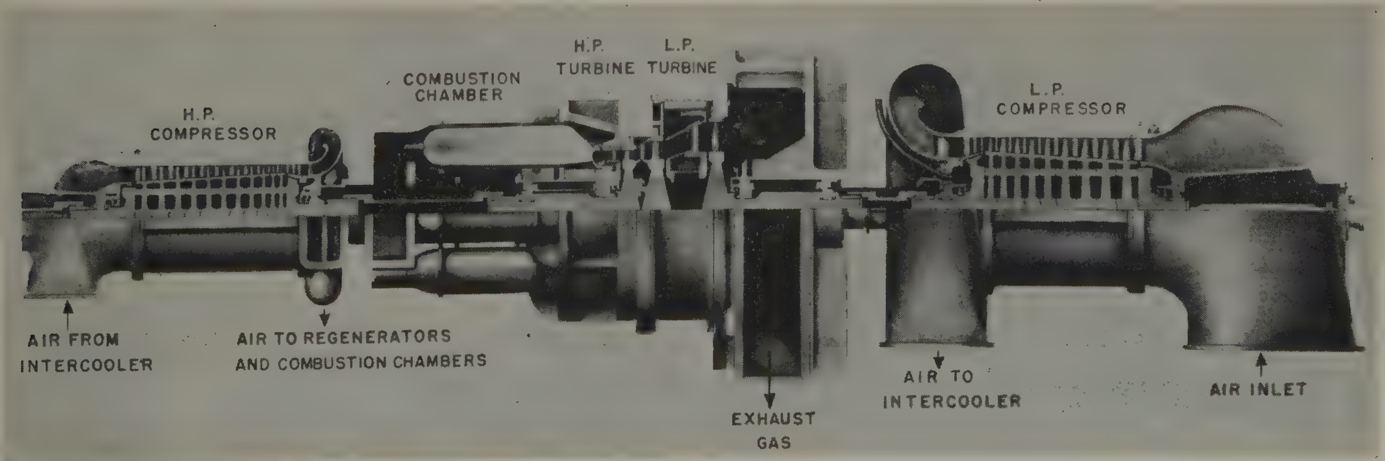


Figure 3. Cross section of 5,000-kw compound-cycle gas turbine for power generation

Figure 4. Aerial view of the Edward M. Graham station, Bangor Hydro Electric Company

conditions, the gas turbine has applications that closely follow the applications for central stations.

FOR MECHANICAL DRIVE

To drive large centrifugal compressors, fans, blowers, pumps, or other mechanical applications, two 5,000-horsepower gas turbines of different characteristics are available. The first is the simple-cycle single-shaft design which operates at essentially constant speed. This unit is best adapted for continuous process applications. The second is either the simple-cycle 2-shaft, or the regenerative-cycle design at higher efficiency, with variable-speed–variable-load turbine characteristics. This unit is better suited to part load or varying load, as well as continuous process operation. Either may be simply adapted for use with a waste heat boiler for process steam recovery.

GAS PIPE-LINE PUMPING

Centrifugal compressors are now available in ratings of 5,000 horsepower at 5,000 rpm. The use of these compressors with a gas turbine is especially adaptable to natural gas pipe-line pumping, see Figure 7. Studies indicate that through the use of the 5,000-horsepower gas turbine fewer units are required for the total gas delivery, with fewer units per station. The lower number of units per station, and the simplified operation of the gas turbine results in fewer personnel, even to the point of full- or semi-automatic operation. This reduces the investment and operating cost per station to a point which permits closer spacing of stations of less horsepower. This results in less pressure drop between stations, with lower transmission losses. Consequently, more gas can be pumped with a given horsepower, or a given quantity of gas can be pumped in a smaller pipe line, again resulting in large savings in material and investment costs.

The gas turbine is also being applied in existing lines as a booster unit spaced midway between present stations, to be operated during periods of peak load, or to increase the maximum capacity of the line. The addition of a 5,000-horsepower booster station may increase the capacity of an existing line by 25 per cent at much less capital expense than by installation of parallel lines.

GAS TURBINE LOCOMOTIVES

A 4,500-traction-horsepower plant in a single locomotive cab, only 83 feet between couplings, will permit handling longer, high-speed freights of greater revenue tonnage, over long distances at lower cost. The smooth, powerful pull of the electric drive with greater horsepower per ton on drivers in a single cab unit, and with minimum wheel slip, already has proved advantageous.

At the present time, the pilot model and the first production models have demonstrated their ability to haul heavy tonnage over mountain grades, see Figure 8. They are expected to show lower maintenance costs due to the lightweight rotating elements, and low operating costs per ton-mile due to the lower cost of fuel.

USE WITH AN EXHAUST HEAT RECOVERY BOILER

The gas turbine cycle inherently discharges large quantities of hot gas. For instance, the 3,500-kw simple-cycle gas turbine discharges up to 340,000 pounds per hour of gas at temperatures up to 800 degrees Fahrenheit. This hot gas contains almost 60 million Btu's per hour above the standard ambient of 80 degrees Fahrenheit.

By directing this hot gas from the turbine exhaust through a properly designed, nonfired, exhaust-heat recovery boiler, from 25,000 to 40,000 pounds of steam per hour may be obtained at very little increase in fuel consumption. Thus the gas turbine has application in a wide

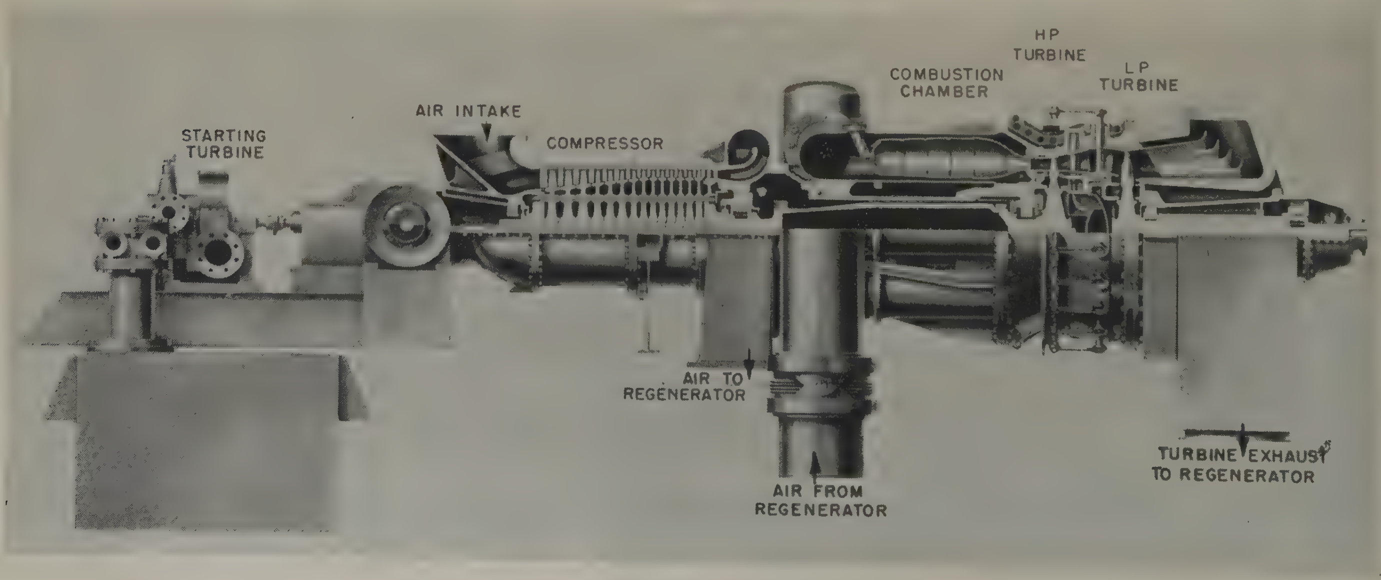


Figure 5. Cross section of 2-shaft 5,000-horsepower regenerative-cycle gas turbine with independent load shaft for mechanical drive

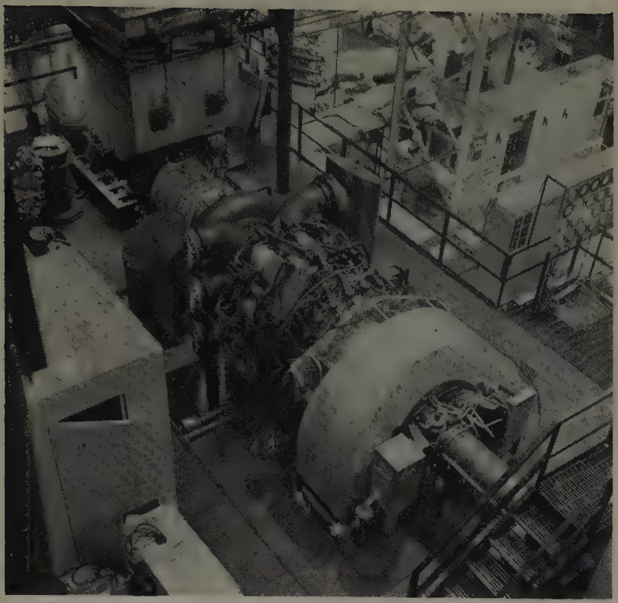


Figure 6. First 2-shaft 3,500-kw regenerative-cycle gas turbine-generator unit on factory test stand

field among those industries requiring steam for process in manufacture,[8] see Figure 9.

A variation of this use has already been in successful operation for several years, and a duplicate equipment has been installed. At the Belle Isle station of the Oklahoma Gas and Electric Company, see Figure 10, the capacity of the 50,000-kw steam station was increased over 6,000 kw,[2] with an improvement in over-all heat rate, by heating a portion of the boiler feed water for the steam turbines to 325 degrees Fahrenheit from the gas turbine exhaust. The installation of the second gas turbine in this station will increase the output and improve the station efficiency still more.

The steam which can be recovered from the gas turbine exhaust can be further increased during peak manufacturing requirements, with the use of supplemental fuel firing. Studies indicate that for low-pressure steam, up to 250 pounds pressure, about 10 to 12 pounds per kilowatt-hour may be obtained from gas turbine exhaust very cheaply.

Based on the proper choice of an exhaust heat recovery steam boiler design, the combined gas-turbine–steam cycle will offer over-all efficiencies as high as 50 to 70 per cent for both the electric power and steam recovery, see Table I.

ADVANTAGES OF THE GAS TURBINE

The gas turbine has many advantages not possessed by other prime movers of equal power. Briefly these are

1. The gas turbine is small in size and light in weight. The 5,000-kw compound-cycle unit is only 50 feet long, 27 feet wide, and less than 14 feet high, and may be installed with a 15-ton crane, with a 21-foot crane lift. The 3,500-kw simple-cycle unit is 47 feet long and 10 feet wide.

2. Only a small, inexpensive building is required. A 2-unit 10,000-kw station has been built measuring only 102 by 109 feet, with a 34-foot roof. This includes two low-roof wings for station services and auxiliaries, heating boilers, for storage and wash rooms, and for controls.

Table I. By-product Power When Furnishing 100,000 Pounds Per Hour Steam at 150 Pound Gauge Plus 100,000 Pounds Per Hour Steam at 50 Pound Gauge for Process, by Different Systems

	Net Kw	Tons Coal/Hr.	Btu/Kw for Power
150 psig boiler reducing valve	0	10.67	
400 psig—600 degrees extraction–back-pressure turbine	4,500	11.50	4,700
1,200 psig—840 degrees extraction–back-pressure turbine	9,700	12.40	4,400
Gas-turbine with 2 pressure waste heat boilers and economizer	17,000	17.0	7,400

3. The gas turbine can be started quickly, in a matter of 15 to 30 minutes, and may be shut down at the end of a run, with no stand-by losses. This is a big advantage in stand-by or peaking service.

4. Minimum personnel is required. The starting and supervisory controls, furnished as a part of the gas turbine, are semiautomatic in operation, and include automatic recording of the most important temperatures and of vibration, with automatic warning and protection.

5. Total installed costs are low. The gas turbine is

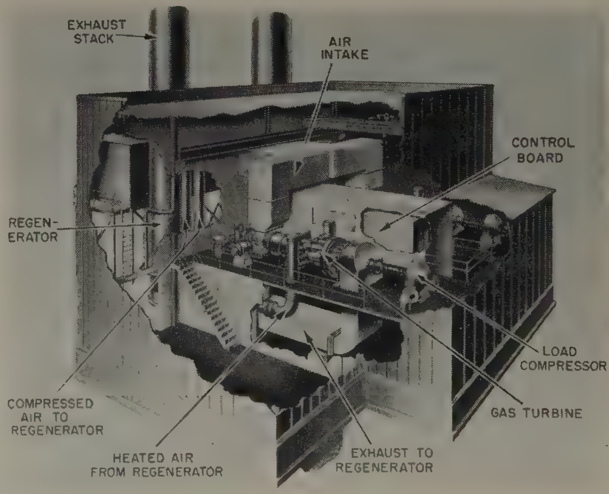


Figure 7. Self-contained 10,000-horsepower gas turbine pumping station

Figure 8. A 4,500-horsepower gas turbine-electric locomotive hauling heavy tonnage freight across Green River, Wyo., bridge of the Union Pacific Railroad

supplied complete with prefabricated piping for all oil, cooling water, fuel, hot air, and gas pipes within the outlines of the machine, and all connections to and from the regenerators. Starting and supervisory controls for the gas turbine and its operating auxiliaries are also a part of the equipment. The purchaser supplies starting and emergency control power supply, fuel system and auxiliaries, cooling water supply with circulating system, and the usual electric switchgear equipment. As a part of the purchaser's building, he also supplies intake air and exhaust ducting, and all local station services and auxiliaries.

6. The gas turbine requires a minimum of cooling water supply, and can be operated with a closed circulating system, employing a fan-cooled heat exchanger. The 3,500-kw generating power plant usually requires only 400 to 450 gallons per minute of cooling water; the 5,000-kw unit with intercoolers requires only about 1,200 gallons per minute. Thus, the gas turbine may be used where water is scarce or difficult to develop, as at remote load centers.

These, and other advantages for particular installations, must be given full consideration for each application.

WHAT INDUSTRIES WOULD GAIN MOST FROM THE GAS TURBINE

In a short article of this type it is only possible to suggest, but not fully analyze the industries that might best consider use of the gas turbine. Looking at its function as a prime mover, in addition to its use in the central station for power generation, or in combination with a waste heat boiler for process steam, the following are a few of the industries which seem to offer greatest opportunity for its application and use:

1. The petroleum industry for power, for process steam in refining, and for mechanical drive of compressors either in the refining process, or oil field repressuring.

2. The paper industry for power, and for the multiple uses of process steam for cooking, washing, drying, finishing, and so forth.

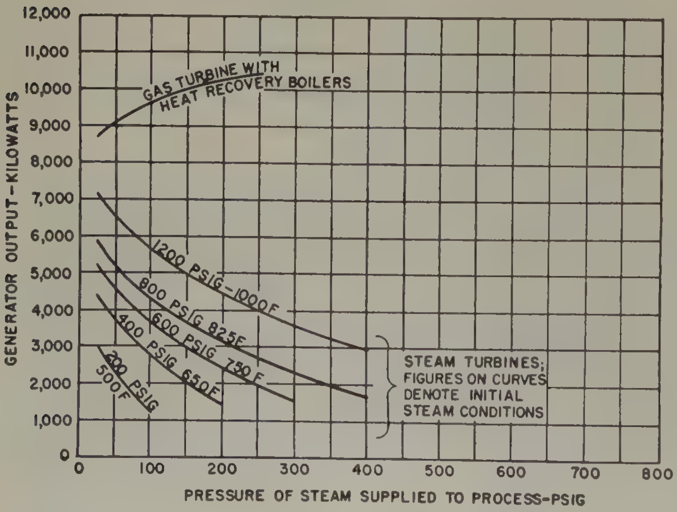


Figure 9. Electric power which can be generated by gas or steam turbines when supplying 100,000 pounds of steam per hour for process

Figure 10. Aerial view of Belle Isle station showing the small wing which houses the 3,500-kw gas turbine

3. The rubber industry for power and for process steam in treating and vulcanizing.

4. The building materials industry for power and for steam in the processing of building boards, roofing, and particularly for molded wood or plastic products, especially for use or conversion of waste into marketable products.

5. The food industry, where quantities of low-pressure steam are used for cooking, washing, sterilizing, and evaporating.

6. The steel industry, for electric power and mechanical drive of centrifugal compressors, as well as process steam for operation of low-pressure steam turbines, drop hammers, presses, hoists, and so forth.

In many instances a combination can be worked out between the central station which can generate and distribute power, and the industry which can use the process steam recovered from the gas turbine exhaust heat. Each application should be carefully studied both economically and practically, in comparison with existing and alternate methods of securing the desired result.

The gas turbine is a new prime mover with many attractive advantages. It is not suggested that it will replace other present successful sources of power or that it will revolutionize industry. Even at this early stage of its development, however, it gives promise of supplementing the available well-known prime movers, and to offer special attractions for economic application in many instances.

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2. 3,500-kw Gas Turbine Raises Station Capability by 6,000 Kw, **J. W. Blake, R. W. Tumy.** *Power* (New York, N. Y.), September 1948, pages 64–71.

3. Huey Gas Turbine Ticks Off 3,400 Hours, **J. W. Blake, R. W. Tumy.** *Power* (New York, N. Y.), February 1950, pages 96–100.

4. Huey Gas Turbine Establishes Excellent Operating Record, **J. W. Blake.** *Electric Light and Power* (Chicago, Ill.), volume 28, August 1950, pages 62–8.

5. Regenerative Gas Turbine Efficiently Supplements Hydro, **P. F. Kruse.** *Electrical World* (New York, N. Y.), volume 135, January 1, 1951, pages 54–6, 108.

6. Design Features of a 5,000 HP Gas Turbine, **B. O. Buckland.** *Transactions,* American Society of Mechanical Engineers (New York, N. Y.), volume 70, July 1952, pages 655–61.

7. Gas Turbine—Centrifugal Compressor Stations for Gas Pipeline Pumping, **J. F. Eichelman, J. S. Quill.** *General Electric Review* (Schenectady, N. Y.), volume 54, number 6, June 1951, pages 23–9.

8. The Gas Turbine with a Waste-Heat Boiler, **G. R. Fusner.** *Mechanical Engineering* (New York, N. Y.), volume 70, June 1948, pages 515–18.

Largest Winter General Meeting Ever Held Draws Record Attendance in New York

A total of 88 sessions during which 168 papers and 232 conference papers were presented comprised the technical program of the AIEE Winter General Meeting held in New York, N. Y., January 19–23, 1953. Meeting headquarters was in the Hotel Statler and the overflow of sessions beyond the capacity of the Statler were held in the Engineering Societies Building. The smoker was held at the Hotel Commodore on Tuesday evening, and the dinner-dance in the ballroom of the Hotel Statler on Thursday evening. Inspection trips to places of interest in the city and the vicinity were arranged during the days and theater tickets to the popular shows were made available to out-of-town members during the week of the meeting. The total registered attendance was 4,676 members and guests. This represents a 19.2-per-cent increase over the record attendance of 3,925 for the previous year.

Beginning with a get-acquainted tea on Sunday afternoon, an interesting series of events for the ladies was arranged by the Ladies' Entertainment Committee under the chairmanship of Mrs. E. S. Banghart. Trips were taken to the downtown section of New York and the United Nations, as well as a visit to the shopping area, a fashion show at the Waldorf-Astoria, a dinner, and luncheon at the Tavern-on-the-Green.

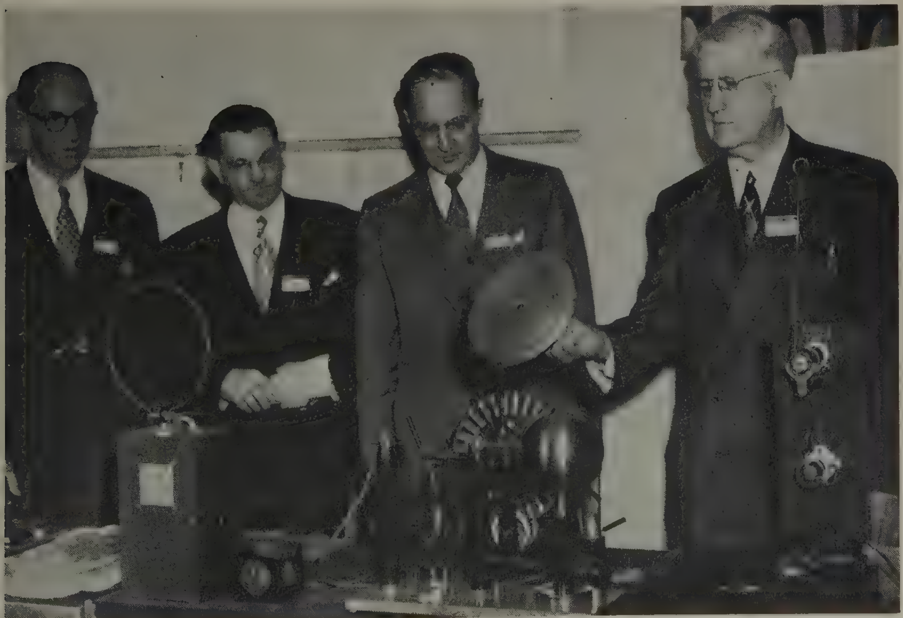
GENERAL SESSION

AIEE President D. A. Quarles, president of the Sandia Corporation, Albuquerque, N. Mex., presided at the General Session on Monday afternoon, January 19. In his introductory address, "AIEE Progress," Mr. Quarles pointed out that AIEE membership has passed the 45,000 mark, a factor which is reflected not only in the increase in the number of technical committees required to carry on the work of the Institute, but in an increase of society activities as a whole. In this respect he discussed recent changes in the organization, particularly those brought about by the approaching retirement of Secretary H. H. Henline, who will be succeeded by N. S. Hibschman, newly appointed Assistant Secretary. The full text of Mr. Quarles' remarks appears on pages 189–91 of this issue.

Edison Medal Presentation. A feature of the General Session was the presentation of the Edison Medal to Dr. V. K. Zworykin, vice-president, technical consultant, and director of the Radio Corporation of America Laboratories at Princeton, N. J., "for outstanding contribution to the concept and design of electronic components and systems." In accepting the award, Dr. Zworykin said that it was not only a recognition of his individual work, but more properly "a measure of the impact on present-day society of television, the primary objective of many men besides myself."

Highlights of Dr. Zworykin's life were given by his associate at the RCA Laboratories, Dr. E. W. Engstrom, vice-president in charge of research, and the history of the Medal was outlined by Professor J. F. Calvert of Northwestern University, chairman of the Edison Medal Committee. The Edison Medal addresses are presented in full on pages 207–09.

Institute Paper Prizes. Chairman E. I. Green of the AIEE Committee on Award of Institute Prizes described the basis for these awards and announced the winners. First prize for the Best Student Paper went



At the Winter Meeting session on Electrostatic Hazards in Hospital Operating Rooms, P. G. Guest (right) of the United States Bureau of Mines demonstrates that a spark can produce an explosion if the charged mass of metal is large enough to store the required energy. With Mr. Guest are, left to right: Robin Beach, Robin Beach Engineering Associates; Hendley Blackmon, Westinghouse Electric Corporation; and Dr. C. W. Walter, Peter Bent Brigham Hospital

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Future AIEE Meetings

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 20–21, 1953

Southern District Meeting
Seelbach Hotel, Louisville, Ky.
April 22–24, 1953
(*Final date for submitting papers—closed*)

North Eastern District Meeting*
Sheraton Plaza Hotel, Boston, Mass.
April 29–May 1, 1953
(*Final date for submitting papers—closed*)

AIEE-IRE-RTMA-WCEMA West Coast Electronics Conference
Shakespeare Club, Pasadena, Calif.
April 29–May 1, 1953

Northern Textile Conference*
Sheraton Plaza Hotel, Boston, Mass.
May 1, 1953

* Concurrent and co-ordinated meetings.

AIEE-IRE Telemetering Conference
Edgewater Beach Hotel, Chicago, Ill.
May 20–22, 1953

Conference on Electric Heating
Detroit-Leland Hotel, Detroit, Mich.
May 26–27, 1953

Summer General Meeting
Chalfont-Haddon Hall Hotel, Atlantic City, N. J.
June 15–19, 1953
(*Final date for submitting papers—March 17*)

Pacific General Meeting
Hotel Vancouver, Vancouver, British Columbia, Canada
September 1–4, 1953
(*Final date for submitting papers—June 3*)

Middle Eastern District Meeting
Daniel Boone Hotel, Charleston, W. Va.
September 29–October 1, 1953
(*Final date for submitting papers—June 30*)

Fall General Meeting
Muehlebach Hotel, Kansas City, Mo.
November 2–6, 1953
(*Final date for submitting papers—July 6*)

(Left) AIEE President D. A. Quarles (second from right) presents the Institute's top award, the 1952 Edison Medal, to Dr. V. K. Zworykin of the RCA Laboratories for "outstanding contributions to the concept and design of electronic components and systems." At extreme left is Professor J. F. Calvert of Northwestern University who gave a history of the Medal. At extreme right is Dr. E. W. Engstrom of RCA Laboratories who gave highlights of Dr. Zworykin's career. The presentation took place at the general session of the Winter General Meeting. (Right) Among those who took part in the recent Winter General Meeting were, left to right: J. A. Parrott, general sessions chairman; Dr. H. T. Heald, Chancellor of New York University, who gave the keynote speech at the general session; President Quarles; and C. T. Hatcher, general chairman of the meeting

to M. J. Wiggins, University of Florida, for "Magnetic Tape Sound for 16-Millimeter Motion Pictures"; second prize to A. R. Engquist and R. S. Christy, "Characteristics of the Radion Tube Preliminary Report."

Institute prizes, awarded on a Division basis, were as follows:

Communications Division. First prize, J. J. Pilliod, American Telephone and Telegraph Company, "Fundamental Plans for Toll Telephone Plants"; second prize, F. F. Shipley, Bell Telephone Laboratories, "Automatic Toll Switching Systems."

Official United States Navy photo

Captain J. W. Boundy, commanding officer of the United States Naval Supply Depot, Bayonne, N. J., with Delavan Halloran, one of a group of AIEE members who visited the facility during a Winter Meeting inspection trip on January 21

General Applications Division. First prize, C. C. Whittaker and W. M. Hutchison, Westinghouse Electric Corporation, "The Pennsylvania Railroad Ignitron-Rectifier Railroad"; second prize, F. D. Gowans, B. A. Widell, and A. Bredenberg, General Electric Company, "A New Electric Locomotive for the Pennsylvania Railroad."

Power Division. First prize, R. A. Baudry, P. R. Heller, H. K. Reamey, Westinghouse Electric Corporation, "Improved Cooling of Turbine-Generator Windings"; second prize, P. H. Jeynes, Public Service Electric and Gas Company, "Evaluation of Capacity Differences in the Economic Comparison of Alternative Facilities."

Science and Electronics Division. First prize, E. W. Clark, General Electric Company, "A High-Sensitivity Ratio Instrument for Industrial Resistance Thermometers"; second prize, A. R. Eckels, North Carolina State College, and I. S. Blumenthal, Northrop Aircraft, Inc., "A High-Speed Direct-Writing Oscillograph."

Keynote Speaker. Henry Townley Heald, Chancellor of New York University, and former president of the Illinois Institute of Technology, Chicago, in his role as keynote speaker discussed "Education and Public Policy." In his address, presented as the United States entered upon a new era in its political history, Dr. Heald reminded us that "the future of American education and its continued success in fulfilling its vital function in our society are closely related to the national policies which we adopt." He went on, in the main portion of his speech, to consider some of the problems which face higher education today and with which, in some measure, the new administration will have to deal.

For the full text of Dr. Heald's address, see pages 196–9.

TECHNICAL PROGRAM

The subject matter in technical sessions ranged through practically the entire gamut of Institute technical activities and a number of sessions were sponsored by technical committees in each of five broad divisions: communication, general applications, industry, power, and science and electronics. In addition, five sessions were sponsored by the general committees in the fields of education, management, safety, and standards. The session on electrostatic hazards in hospital operating rooms with the demonstrations of how explosions occur evoked considerable interest. Three papers in the conference on education, which dealt with specialization on fundamentals and questioned the value of options as well as integration versus options, were timely and in keeping with changing conditions.

Communication Division. Among the eight sessions in this division, two were devoted to television: one on the newly released ultra-high-frequency system, and the second on different aspects of color television transmission.

Two sessions were devoted to communication switching systems, one of which embraced four papers by engineers in the Bell Telephone Laboratories. Cross-country dialing was demonstrated as well as the maze-solving electric mouse and automatic error detecting and correcting. Other sessions dealt with radiocommunication systems, special communication applications, and telegraph systems.

In another session, engineers of the Bell Telephone Laboratories treated the *L3* coaxial system from the point of view of system design, the amplifiers, equalization and regulation, as well as the television terminals.

General Applications Division. Four sessions in this division were in the field of transportation and the papers dealt with timely subjects such as rapid-transit systems, design features in connection with diesel locomotives, as well as training for their maintenance, and vertical transportation such as elevators and escalators. Two other sessions in the field of production and application of light on the industrial side dealt with ultraviolet and infrared radiation; on the lighting side the papers dealt with filament, mercury-vapor and fluorescent sources, and also ballasts and circuit-controlled devices.

Industry Division. Among the 12 sessions of the Industry Division, great interest was shown in the sessions on feedback-control systems and industrial control. Another session on petroleum industry dealt with generation, distribution, the electric equipment, and protection against fires in refineries. Other sessions treated industrial power systems, general industrial applications, cathodic protection, and electrochemical processes.

Power Division. The subject matter in 27 sessions of this division ranged throughout the entire breadth of this field of activity. Papers embracing new principles of design, theory, and operation, including the economics involved for systems of several different voltage levels, were presented. Sessions also dealt with insulated conductors, and the associated apparatus of power systems such as relays, switchgear, transformers, and protective devices in addition to some of the newer insulating materials of both the solid and liquid forms. Several valuable guides and important standardization work were presented.

Great interest was shown in the sessions which dealt with speed-governing load control and tie-line operation.

Science and Electronics Division. In this division, 30 sessions were held and in the realm of basic sciences, there were sessions on applied mathematics, electric circuit theory, basic concepts, magnetic materials, and some of the newer dielectrics which have application in the 60-cycle field and the high-frequency field. In the field of rectification and conversion there were sessions on electronic power converters in substations, metallic rectifiers, and two sessions on semiconductors with papers on the theory and properties of photoconductors, multielectrode transistors, germanium junction diodes, and *P-N* junction diodes. The sessions on magnetic amplifiers and saturable reactors evoked a great deal of interest. A review of the fundamentals of magnetic amplifiers was presented by three well-known authors for educational purposes.

Sessions on nucleonics, electrical properties of gases, and nuclear instrumentation, as well as the applications of instruments and measurements in the field of medicine and biology, were held also.

In the realm of electronics, much interest was shown in a session devoted to the complexity of electronic systems where the points of view of the designer, the manufacturer, and the user were presented. Five representatives of the armed services outlined their reasons for demanding reliability of equipment and the manufacturers told about their constant search for better components and methods of construction. Other sessions on high-vacuum tubes and gas tubes were of considerable interest.

In the rapidly expanding field of computing devices, four sessions were held, two of which dealt with analogue computers and digital computers. Still another session dealt with the applications of these computers to various problems including aircraft design and stability. The fourth session treated some of the noncalculative applications of computers including the use of Univac on election night, which was of more than usual interest because of the large number who witnessed the results.

WINTER GENERAL MEETING COMMITTEE

Members of the General Committee and the chairmen of the working committees were as follows: General, C. T. Hatcher (Chairman), A. J. Cooper (Vice-Chairman), J. J. Anderson (Secretary); Budget Coordinator, W. J. Barrett; Vice-President, AIEE District 3, M. D. Hooven; Publicity, G. T. Minasian; General Session, J. A. Parrott; Dinner-Dance, J. G. Derse; Inspection Trips, D. E. Sullivan; Smoker, C. F. Bolles; Theater-Radio-Television, J. G. Aldworth; Hotel Accommodations, W. G. Vieth; Registration and Checkup, H. E. Martin; Ladies' Entertainment, Mrs. E. S. Banghart; Monitors, R. T. Weil; Philadelphia Representative, J. B. Harris, Jr.; Committee on Technical Operations, L. F. Hickernell.

Publications, Standards, Among Subjects at Forum of Technical Committee Chairmen

Technical operations procedures, size of Winter General Meeting and location of Fall meeting, publications, and Standards work were discussed at the Forum of Technical Committee Chairmen held on Wednesday evening, January 21. Director L. F. Hickernell, chairman of the Committee on Technical Operations, presided.

TECHNICAL OPERATIONS PROCEDURES

In connection with the work of the Committee on Technical Operations, Chairman Hickernell briefly reviewed the following matters: a manual of "Technical Operations" in preparation; the increase in the attendance at special technical conferences as compared with the attendance at District meetings; the publication of reports of special technical conferences; a recapitulation of the budget forecast for papers; procedures for approval of nonmember authors and nonmembers on subcommittees; procedure for appeal in cases of rejected papers; revision of rules for prize awards; classification of papers; and deadline dates for reviews and program information to be announced.

In conjunction with the Student Prize Papers, the Member-for-Life fund has made it possible to send the winners of the Student Paper Prize in each District to the Summer General Meetings. As the sessions at which the prize-winning papers were represented have not been well attended in the past, it was proposed to introduce the winners at the General Session and not to have them represent the papers.

With respect to an opportunity to discuss conference papers, Chairman Hickernell explained that the same opportunity prevailed as for the discussion of *Transactions* papers if the conference papers were reviewed, preprinted, and announced in ad-

Philadelphia Section Women's Auxiliary

Members of the Women's Auxiliary of the AIEE Philadelphia Section will be official hostesses at the Summer General Meeting in Atlantic City, N. J. Shown here making plans for the event are, seated in front row, left to right: Mrs. H. R. Paxson, Board Chairman; Mrs. H. H. Sheppard, Junior Past Chairman; Mrs. L. R. Gaty, Chairman, Membership Committee; Mrs. C. T. Pearce, Chairman, Ways and Means Committee; Mrs. G. B. Schleicher, Chairman, Program Committee. Back row, left to right: Mrs. W. F. Henn, Chairman, Education Committee; Mrs. O. A. Huntsman, Chairman, Hospitality Committee; Mrs. C. R. Kraus, Historian; Mrs. T. R. Whitehurst, Chairman, Publicity Committee. Board members not present: Mrs. W. F. Denkhaus, Vice-Chairman; Mrs. R. J. Trasatti, Corresponding Secretary; Mrs. S. E. Moore, Recording Secretary; Mrs. J. A. Graves, Treasurer

vance, and represented the same as are the *Transactions* papers.

WINTER AND FALL GENERAL MEETINGS

To introduce this topic, Chairman Hickernell pointed out that the number of sessions on the Winter General Meeting program was in excess of the capacity of the Hotel Statler and that this presented several alternatives. One alternative was to limit the number of parallel sessions to a maximum of eight. Another alternative was to utilize the Engineering Societies' Building for the overflow of 16 sessions or to hold these extra sessions in nearby hotels. Still another alternative was to increase the size of the Fall General Meeting program, which is one of the reasons for which it was initially instituted, and still another was to hold evening sessions such as is successfully done by sister societies.

In discussion of the matter, opinion was expressed that the separation of the sessions in other buildings was undesirable but that if such a separation could be announced in advance, it might be practicable. Another suggestion was to hold sessions on certain subjects only in different locations and still another view expressed was to the effect that it would be advantageous to have fewer meetings with a larger attendance. In response to a question, Chairman Hickernell explained that it would be necessary to request the Entertainment Committees to rearrange the evening functions to provide two evenings to take care of 16 sessions. Professor Dow emphasized the importance of the social activities and explained that technical people who come to New York would prefer to have the evenings free for enjoyment.

In reference to the location of the Fall General Meeting, Chairman Hickernell expressed the view that the meeting had often been held too far away from industrial centers to attract audiences and that the July closing date for the initial receipt of papers from authors has been disadvantageous. He proposed for consideration the holding of the Fall General Meeting in a fixed location such as Chicago, Ill.; if held there year after year, people would become accustomed to the location and could make their plans accordingly. Director A. C. Muir favored the idea; for example, the Industry Division had held successful meetings in Pittsburgh, Pa., Cleveland, Ohio, and Detroit, Mich. However, Professor Dow pointed out that the National Electronics Conference, which is partly sponsored by the Institute, draws heavily on electronics people, and is held every fall in Chicago. He suggested that holding the Fall Meeting in different locations makes the Institute a national society and it was further suggested that the Fall Meeting should assume more of the nature of a special technical conference and concentrate on specialized subject matter. Chairman Hickernell expressed the view that breaking up the General meetings into specialized subject matter would lead toward loose organization unity.

Elgin B. Robertson, chairman of the Committee on Planning and Co-ordination, explained that when the Fall Meeting was originally established it was the intention that it should be held in various locations in the Midwest in order to bring the Institute to the membership and also to relieve the load of papers on the program of the Winter General Meeting. However, when the meeting was held in New Orleans or Chicago, the Texas people did not attend, and Mr. Robertson confessed that perhaps holding the meeting in various different locations is more desirable theoretically than it is practical.

After the discussion, an expression of opinion obtained by an informal vote showed the following results: The first alternative, or limiting the number of sessions at the Winter General Meeting to eight, showed 23 in favor and 28 against.

Only seven were in favor of holding evening technical sessions.

On the question of holding overflow sessions elsewhere, opinion was evenly divided; 17 favored the Engineering Societies' Building location and 17 favored nearby hotels.

PUBLICATIONS

With regard to the new bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, which were inaugurated last July, Chairman McEachron said that the committee had not received any comments, either favorable or unfavorable, and he called for an expression of opinion. There was approximately a 40-per-cent return to the Technical Division Publications Questionnaire of 2 years ago and a distribution of 17,000 bimonthly publications without charge indicates that only 38 per cent of the membership is taking advantage of this service. The distribution of each of the three bimonthly publications is as follows:

	Free	Paid	Total
Communication and Electronics	6,751	635	7,386
Applications and Industry	4,008	1,394	5,402
Power Apparatus and Systems	6,647	913	7,560
	17,406	2,942	20,348

Dr. McEachron pointed out that the average cost of the bimonthly publications per page is a little less than $40 and the total estimated yearly cost of the three publications approximately $94,000.

The question was raised by Director Victor Siegfried as to whether the members had been adequately advised that they could receive one of the three bimonthly publications without charge. Dr. McEachron explained that the availability of the bimonthly publications has been announced each month in *Electrical Engineering* on the "Highlights" page.

W. R. Brownlee, chairman of the Power Division Committee, suggested that when members attending the forum return to their Sections, they draw attention to the availability of the bimonthly publications. The procedure was believed desirable provided that members who subscribe actually would use the publications and not order them wastefully.

Professor Dow expressed the opinion that the circulation and periodical issuance of the new bimonthly publications provided an attractive medium for young technical people and graduate students to publish the results of their work.

DISTRIBUTION OF CONFERENCE PAPERS

The authors of conference papers on the Winter General Meeting program had been asked if they were willing to bring 100 copies of their papers with them for distribution at the meeting, and also if they were willing to mail up to 100 copies in answer to written requests received after the meeting and to keep a record of the number of copies mailed. From the data so far obtained from 129 authors, only 21 were unwilling to furnish their papers in any form and eight others were unwilling to mail out copies after the meeting. A partial list of authors willing to supply copies, and their addresses, appears in this issue (*pp 263–6*); a supplementary list is scheduled for April. In this way about 60 per cent of the papers will be made available. It appears that after 6 months' time some indication will have been obtained as to the probable demand for conference papers.

In discussion, the suggestion was made that the authors be asked to provide 100 or 200 copies for distribution by Headquarters and that a form be sent out at the time the mailed announcements go forward. Chairman McEachron explained that Headquarters does not have the space nor the facilities to handle the conference papers on a mail-order basis. P. L. Alger suggested that the conference papers should be printed if made available on time and C. E. Dean suggested that the committees should put more effort and emphasis on the value of making conference papers available. In conclusion, Chairman McEachron pointed out that many conference papers are not written and are given verbally. In the case of *Transactions* papers, they are received in advance, reviewed, and the manuscripts are complete with original illustrations ready for publication. Of 52 conference papers invited on December 16 for consideration for publication in *Electrical Engineering*, only eight had been received by January 21 and but five of the eight were immediately useable. The remainder were unsuitable because of length and the lack of original illustrations.

MICROFILMING OF CONFERENCE PAPERS

With reference to suggestions for the microfilming of conference papers, Chairman McEachron said that the matter had been investigated. Microfilm is convenient for storage in a small space and it would be possible to have all of the conference papers of a convention microfilmed on one negative reel at a cost of $15 or $20, which would be the equivalent of 3,500 unbound pages. However, when it comes to the distribution of small orders for three or four papers, these would have to be first located on the reel, then printed and collated so that, with the minimum charges that obtain, a cost of $15–$18 could be developed easily. The editor had been in touch with Mr. Phelps, Librarian of the Engineering Societies Library, and Ralph Caruthers of the New York Public Library, as well as Mr. Gunderson of the Recordak Corporation, and all three were in agreement that microfilm is not practical for the distribution of single copies of several hundred different papers to 100–150 individuals in various locations. The view was expressed by Chairman McEachron that if the desire was to preserve papers for future use, the committees should see to it that the papers become *Transactions* papers.

ONE-PAGE DIGESTS

To open the discussion, Chairman McEachron explained that many of the 1-page digests received are either too short or too long and that some authors seem unable to prepare suitable digests. With the advent of the bimonthly publications, there was some feeling that the digests might be eliminated and shorter abstracts of all papers substituted; however, this would result in solid pages of abstract material without illustrations which likely would not be read.

C. E. Dean was of the opinion that the 1-page digests are an effective means for those in one field to keep informed about what is going on in other fields. Another speaker concurred in this view in that the digests give the reader the gist of a paper. Professor Dow believed the digests could be abolished as the full papers were available to the membership in the bimonthly publications. Dean W. A. Lewis expressed the belief that the digests are too long to give one the gist of the papers and too short to be effective for those interested in the details. He suggested that there should be about six abstracts to the page. It was believed that the abstracts could be put in the advertising section and be of any length. It was pointed out that this would result in the abstracts becoming longer and longer and the material might be objectionable from an advertising point of view.

STANDARDIZATION WORK

The discussion of this subject was opened by M. M. Brandon, chairman of the Standards Committee, who said that on the basis of a communication received from the chairman of the Committee on Rotating Machinery the technical committees do not have any direct liaison representation on the American Standards Association (ASA) sectional committees. The chairman of the Rotating Machinery Committee, C. G. Veinott, felt the technical committees should have responsibility for the preparation of Standards. They do have this responsibility when the Standards are AIEE but they do not have the responsibility when Standards are jointly sponsored with other societies.

The chairman of the Transformer Committee, F. J. Vogel, explained that his committee did not have liaison representatives appointed because proposed Standards went through without difficulty. He expressed the belief that anybody should be able to initiate changes in the Standards but that if changes were being discussed by representatives and not reported to the apparatus committees, then the procedure is not proper. Chairman Brandon pointed out that every technical committee has a representative but that the chairman of the technical committees changes every 2 years whereas the representatives continue on for longer periods of time.

The ASA procedure was explained by E. B. Paxton, a past chairman of the Standards Committee. Since the Electrical Standards Committee of the ASA was set up, a number of prominent Standards have been passed under the sponsorship of the sectional committees. When an American Standard is obtained, a more composite Standard results than if sponsored by any one organization and the sectional committees are glad to receive proposals for changes in Standards from any source. He believed that more might be done in the way of liaison representation and that perhaps more AIEE representatives were needed. If the liaison representatives would bring the problems to the Standards Committee, many of the difficulties could be worked out. In conclusion, Director Hickernell believed that some of the difficulties may have been due to too rapid expansion and growing pains and he suggested formalizing some of the procedures which have been taking place informally.

REVISION OF INFORMATION FOR AUTHORS

It was explained by Chairman Hickernell that the revision of "Information for Authors" as contemplated would contain the salient features for the preparation of papers divided into three sections for ready use: (1) for the author; (2) for the stenographer; and (3) for the draftsman. The booklet would be reproduced in a size suitable for combination with the "Manual of Technical Operations."

As there are six sets of graphical symbols in the Standards for use in different areas and abbreviations which are commonplace in one area might not be understood in other areas, Dr. McEachron called for an expression of opinion as to the type of information which should be included. Dean Lewis raised the question as to whether all of the letter symbols for electrical quantities were included in the booklet, and he expressed the belief that the graphical symbols in each of the different areas or fields of endeavor should be included. The editor said that the letter symbols for electrical quantities are in the present booklet, but that it would not be possible to include all of the graphical standards in the different areas. In so far as possible two or three typical circuit diagrams in different areas would be shown and references would be given to the several Standards employed. C. G. Veinott reported that he had used the present booklet recently and had found it quite complete and satisfactory.

Akron Section Student Awards

Ray Miller (center) and Curtis Ivey (right), seniors at the University of Akron, Ohio, receive awards of $10 and $15, respectively, for technical research papers presented before a joint meeting of the AIEE Akron Section and Student Branch on January 15, 1953. The awards, which are made annually by the Akron Section to encourage independent research by engineering students at the university, are being presented by Section Chairman J. C. Hall. Mr. Ivey's first-place paper was entitled, "Two-Speed Synchronous Motor Control." Third-place award went to Robert Savoy

Sections Committee Discusses Student Branches, Membership Growth, at Meeting on January 20

The establishment of two new Sections, reports on Institute affairs, Section operation and management, and other Section activities including a proposed constitutional amendment and amendments to sections of the Bylaws were discussed at a meeting of the Sections Committee held on January 20. Director C. S. Purnell, chairman of the Sections Committee, presided. Preceding the meeting, a movie on the features of Atlantic City, N. J., where the Summer General Meeting will be held, was shown and it was announced that the film is available for the Sections.

The recent death of Vice-Chairman H. A. Dambly, who had rendered valuable services in connection with a number of projects, was announced and the committee voted to draw up a suitable resolution of condolence to be sent to the family.

FORMATION OF NEW SECTIONS

In accordance with established procedure, the committee recommended to the Board of Directors and the Board subsequently approved of the formation of the Mobile-Pensacola Section and the formation of the Hamilton Section. The formation of the latter will become effective on May 1.

On recommendation of the chairman of the Philadelphia Section, the committee approved the formation of the Atlantic City Division of that Section.

INSTITUTE AFFAIRS

The meeting was addressed by President

Quarles, who called attention to the importance of vertical communication in industry today. It is very important in industrial organizations to transmit information from the top level to people next in line on through to the bottom of an organization and to have them bring back information truly and faithfully in respect to their own thinking. Vertical communication has a distinct place in the organization of the Institute where it is important that those who translate policies and pass them on down should bring back from the members in the Sections their reflections on matters through the excellent Sections organization.

President Quarles said that he regretted his inability to visit more Sections, but that he hoped that the work through the chairmen and vice-presidents would pull the organization together in a vertical sense. With respect to the public, publicity is at the focal point of vertical communication.

Finances. Treasurer W. J. Barrett, until recently chairman of the Finance Committee, reported that Institute finances are in good condition and that we were able to meet our obligations and stay out of the red. Last October, for the first time, the budget exceeded the $1,000,000 mark; also, a recent 8-per-cent advance in printing prices will add $16,000 to expenses of the current year. He referred to the serious consideration being given to adjustment of the dues for the Affiliate grade from $15 to $10 to put the grade on a par with that of Associate Members.

Geographical Redistricting. The need for geographical redistricting and the problems involved were discussed by Elgin B. Robertson, chairman of the Planning and Co-ordination Committee. Rapid growth of the Institute has brought about the need for a study of geographical redistricting. As the Sections grew in number, it became impossible for the president to visit them and this responsibility was shifted to the vice-presidents. Now, in several Districts it has become an impossible task for the vice-presidents to visit the various Sections as they would like to do. However, a change in the number of Districts would bring about a change in the number of Board members. One approach to the problem might be to follow state-line boundaries, but on the other hand there may be a community of interest in border territories which would outweigh the political divisions, or conversely. In conclusion, Mr. Robertson called for suggestions and views on the type of organization for the Institute that would be most desirable.

Procedure in Handling Applications. The procedure in handling membership applications and transfers was explained by A. E. Knowlton on behalf of C. W. Franklin, chairman of the Board of Examiners. It was the point of view of the Board of Examiners that, in the final analysis, the application of a member is a personal relationship and therefore he is the one who should be notified. The special committee comprised of two members of the Board of Examiners and two members of the Sections Committee, which was established to explore the situation, was in agreement with that point of view. The speaker suggested that the Sections could follow the matter by comparing their lists with the postings that appear in *Electrical Engineering* each month and by means of the cards sent from Headquarters every 2 weeks, which inform the Sections of new members in their respective areas.

In conclusion, the secretary of the Board of Examiners suggested that those present consider the matter from the viewpoint of the applicant and ask themselves whether or not they would like to have their immediate associates advised of the fact that they were unqualified for the grade desired.

SECTION OPERATION AND MANAGEMENT

Registration of Young Engineers. The importance of the registration of young engineers was acknowledged by N. L. Freeman, chairman of the Committee on Registration of Engineers, who asserted that the committee needs the help of the Sections and Branches to see that the young engineers are properly informed of the advantages of registration. Last year in a given area out of a total of 4,400 students, only 700 of the graduates availed themselves of the opportunity to take the examinations.

The speaker explained that licensure is for the protection of the public; it was first introduced in Wyoming where a large influx of people who came into the state to develop irrigation projects were not properly qualified. To date, there are approximately 130,000 licensed professional engineers, including 20,000 who are registered in the State of New York. The registrant must have a high-school education, be educated in a recognized school, and be a good citizen who is trustworthy with the knowledge to meet any emergency in his specialized field. In addition, the consulting engineers, of course, must take into account the fiduciary aspects of the profession.

In conclusion, Mr. Freeman described the need for guidance from professional people and said that he would like to organize a list of competent persons all over the country who would be able to explain the purposes of professional registration. Chairman Purnell expressed the hope that everything possible would be done to develop a professional consciousness at the student level.

To meet the needs of the situation, a list of the member boards in each state or territory of the National Council of State Boards of Engineering Examiners would be circulated through the Committee on Student Branches and the Sections Committee so that the Sections and Branches could select qualified speakers on the advantages of professional registration in their respective territories.

Student Branch Activities. In reference to finances, Professor F. W. Tatum, chairman of the Committee on Student Branches, said that the Branches are receiving new allotments of $1 per capita and $25 per Branch patterned after the finance allotments of the Sections. As the same restrictions on the spending of the allotments would obtain for the Branches as for the Sections, he felt that those familiar with Section finances might be able to help the Student Branches.

In discussing membership applications for the Associate grade, Professor Tatum said that the constitution requires graduates to be from schools with approved curricula and that for this country the Board of Directors recognizes the curricula accredited by the Engineers' Council for Professional Development (ECPD). He suggested that those on membership committees should be familiar with the curricula accredited by ECPD. To avoid the embarrassment of soliciting applicants who are not properly qualified, a pamphlet entitled "Accredited Undergraduate Engineering Curricula in the United States" may be obtained from the secretary of ECPD, 29 West 39th Street, New York 18, N. Y., at a price of 25 cents each.

Publicity at the Section Level. The success of the publicity work in connection with the Winter General Meeting was commented on by G. T. Minasian, chairman of the Public Relations Committee. A much better response had been obtained this year than heretofore with more reporters visiting the press room, an announcement on the Dave Garroway television show, and the carrying of a tape recording of Dr. Heald's talk on station *WNYC*. Appreciation for all the help received was expressed by Mr. Minasian and he invited those present to visit the press room.

The speaker also referred to the publicity kit, the newsletter, and a publicity manual which he hoped would be helpful to the Sections. In conclusion, Mr. Minasian said that he would like to have ideas for publicity in local newspapers, and that if there is anything that the Public Relations Committee might do in this respect, he would like to be so advised.

Membership and Transfers. Membership growth over the past few years to a maximum of 45,443 members as of January 1, notwithstanding a decline in student enrollment which has been greater than the decline in enrollment in the colleges, was reviewed by C. Clos, chairman of the Membership Committee. The remarkable growth in membership was attributed to the efforts of the Sections.

The need for the early appointment of chairmen of membership committees in the Sections was emphasized by Mr. Clos, who explained that early in the new administrative year he had prepared a story on procedure to expedite the work of the membership committees which had to be held up because, in the early part of September, 30 per cent of the Sections had not yet appointed the chairmen of the membership committees. By the end of September, there were still eight Sections which had not appointed chairmen and at the date of this meeting there was still one unappointed chairman. Membership committees were urged to use the new membership application forms 131B in all cases. With respect to the appointment of the chairmen of transfer committees, Mr. Clos urged that the Sections appoint men with a view toward permanency for a period of years.

Copies of the new membership information folder were distributed and Mr. Clos paid tribute to the splendid work of W. E. Scholz, vice-chairman of the Membership Committee, who spearheaded the work of preparing the booklet. The Sections were urged to have the membership information booklets available for visitors with membership application forms at the Section meetings.

Section Growth Award Plan. Mr. Clos explained that the awards were made on the basis of the per-cent growth of each Section comprised of: (*a*) an annual per-cent increase in membership; and (*b*) a third of the per-cent improvement in annual meeting attendance.

The per-cent improvement in the meeting attendance figures was based on the attendance figures for the previous year compared with the average attendance for the 3-year period preceding that year. The meeting attendance figures were based on the year ending April 30 and the membership data were as of August 1; hence all Sections were urged to send in their meeting attendance data promptly. Chairman Purnell appointed the following members as a subcommittee on Section Growth Awards: V. L. Ingersoll, Chairman, Fisher Black, C. Clos, Morris Jones, and J. C. Strasbourger.

OTHER SECTION ACTIVITIES

Constitution and Bylaws Amendments. In keeping with the decision of the Board of Directors to reduce the number of members on committees and do away with all ex officio members as well as to bring Section *85* of the Bylaws and Parts *b* and *d* of Section *50* in conformity with present operating procedures, the committee recommended amendments to these sections of the Bylaws and proposed a constitutional amendment to Section *58* of Article *9* of the constitution. The Board of Directors subsequently approved the Bylaw amendments with slight changes.

Recognition of Past Section Chairmen. In recognition of past Section chairmen, the Board of Directors has approved a lapel pin proposed by a subcommittee under the chairmanship of J. P. Neubauer. The pin, which has a grey enamel background with the words Past Section Chairman, encircling the emblem, is available through AIEE Headquarters out of Section funds at a cost of $6 postpaid. It was also disclosed that a certificate in recognition of the services of past Section chairmen has been made up, and the secretary deemed it would be proper to use the design of the emblem on the certificate.

Prize Paper Competitions. Vice-President J. C. Strasbourger advised that the purpose of prize paper competition is to advance the art and that a subcommittee has revised and clarified the rules. He was pleased to see that the rules are now working very satisfactorily at the top level of the Institute. Some Sections feel that a cash award is essential while others believe that cash awards are not an incentive. He suggested that everything possible should be done to encourage the presentation of Student Branch papers.

In discussion of the matter, Professor Quigley of the Notre Dame–South Bend Section suggested that the Sections should help the students. If the Sections have a surplus of a few dollars, this might very well be put into prizes or a dinner for the members and the students. In the New York Section, it was reported that efforts are being made to inform the students more about the engineering profession. A new pamphlet on this subject is in preparation, which it is hoped will be sent to the other Sections. The Philadelphia Section reported that they had eliminated the Section Prize Paper to concentrate on prizes for the students and W. J. Lyman of the Pittsburgh Section reported that they had held a very successful Student Branch Paper Conference. First and second prizes of $50 and $25 were awarded.

Meeting Attendance and Fellowship. An exchange of views took place as to the various ways of obtaining good attendance at meetings. As to methods of encouraging good fellowship, the Fort Wayne and the Ithaca Sections stressed the value of refreshments and dinners. The chairman of the New York Section, J. J. Parrott, pointed out the advantages of conducting courses to obtain good meetings. He emphasized the functions of a good program chairman with imagination and contacts who must spend some time in arranging the right kind of a program with good speakers. The chairman of the Chicago Section, R. R. O'Connor, stressed the need for good publicity and the starting of meetings on time.

Winter Meeting Conference Papers Available Upon Request to Authors

A number of authors who presented conference papers at the recent AIEE Winter General Meeting in New York, N. Y., have announced their willingness to supply copies of these papers upon request. (Conference papers are not scheduled for publication in AIEE *Transactions.*) A list of currently available papers follows. Readers desiring copies should write directly to the respective authors, at the addresses given.

Trends in Rapid-Transit-Car Design
Colonel S. H. Bingham, Chairman, Board of Transportation of the City of New York, 370 Jay Street, Brooklyn 1, N. Y.

Extension of Rapid-Transit Facilities in Metropolitan Boston
S. B. Lent, Assistant Superintendent and Chief Electrical Engineer, Metropolitan Transit Authority, 536 Harrison Avenue, Boston, Mass.

Development of Rapid Transit and Superhighways in Chicago
S. D. Forsythe, Chief Engineer, Chicago Transit Authority, 1165 North Clark Street, Chicago 10, Ill.

Equipment Grounding for Industrial Plants
Lewis J. Carpenter, General Electric Company, Industrial Engineering Department, 1 River Road, Schenectady, N. Y.

Short-Circuit Protection for Industrial Plant Generators
F. P. Brightman, General Electric Company, Industrial Engineering Department, Schenectady, N. Y.

The Effect of Iron Conduit on Single-Phase Circuit Impedance
Edward A. Rochau, Consolidated Edison Company of New York, Inc., Test Bureau—9th Floor, 708 First Avenue, New York 17, N. Y.

Problems Associated With the Installation and Operation of a 6,900-Volt Grounded Neutral Industrial Power System
C. L. Eichenberg, Bethlehem Steel Company, Electrical Department, Bethlehem, Pa.

Specialization on Fundamentals
J. R. North, Commonwealth Associates, Inc., 252 West Cortland Street, Jackson, Mich.

Why Options Anyway?
K. B. McEachron, Jr., General Electric Company, 1100 Lawrence Parkway, Erie, Pa.

AIEE Standard Number 1—Introduction to AIEE Standards. General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machines and Equipment
(Working Group of the Standards Coordinating Committee Number 4)
W. R. Hough, Engineering Vice-President, Reliance Electric and Engineering Company, 1088 Ivanhoe Road, Cleveland 10, Ohio

Optimum Selectivity for Existing Carrier-Current Directional Comparison Relay Channels
(D. C. Pinkerton)
T. Johnson, Jr., General Electric Company, Carrier Current Sales, Building 23, Schenectady, N. Y.

The Diesel Locomotive—What It Has Meant to the Railroads
Charles Kerr, Jr., Westinghouse Electric Corporation 11-L, East Pittsburgh, Pa.

Problems of Design in Residential Electric Heating
H. B. Wilde, Wesix Electric Heater Company, P. O. Box 537, Huntsville, Ala.

Our Experience With Electric Space Heating
Robert H. Giedd, Florida Power Corporation, 101 Fifth Street South, St. Petersburg, Fla.

Electric Space Heating and Resulting System Load Factors
(T. H. Allen, C. D. Anderson, Jr.)
Thomas H. Allen, President, Memphis Light, Gas and Water Division, 179 Madison Avenue, Memphis, Tenn.

Commutation Problems
Carl Roesmiller, Department of Water and Power, City of Los Angeles, c/o Electrical Repair Section, 1630 North Main Street, Los Angeles, Calif.

Magnetic Materials for High-Speed Pulse Circuits
David R. Brown, Massachusetts Institute of Technology, 68 Albany Street, Cambridge 39, Mass.

Stressed Ferrites With Rectangular Hysteresis Loops
(H. J. Williams, R. Sherwood, M. Goertz, F. Schnettler)
H. J. Williams, Bell Telephone Laboratories, Murray Hill, N. J.

Nuclear Power Reactors
John R. Menke, Nuclear Development Association, Inc., 80 Grand Street, White Plains, N. Y.

Effect of European Practices on International Power Rectifier Standards
Lysle W. Morton, Industrial Engineering

Department, General Electric Company, Schenectady, N. Y.

Large Industrial Plant Replaces Electric System
E. N. Walton, Powell River Company, Ltd., Powell River, British Columbia, Canada

Steel Versus Wood Construction for Transmission Lines
Kenneth T. Deutsch, Bureau of Reclamation, Denver Federal Center, Denver, Colo.

A Review of the Use of Wood for Transmission-Line Structures
Ralph G. Yerk, Hughes Brothers, Inc., 210 North 13th Street, Seward, Neb.

Modern 220-Kv Steel Power-Transmission-Line Construction
(Eduard Fritz, A. N. Shealy)
A. N. Shealy, Assistant Superintendent Operation-Transmission, Pennsylvania Water and Power Company, Lexington Building, Baltimore 3, Md.

A Study of Cost of High-Voltage Transmission Lines in Alabama, Using Wood and Steel Structures
(L. B. Murray, C. P. Ussery)
L. B. Murray, Alabama Power Company, 600 North 18th Street, Birmingham, Ala.

Improvements in Performance of Steel and Wood Transmission Lines
C. A. Booker, New England Power Service Company, 441 Stuart Street, Boston, Mass.

Wood Versus Steel 115-Kv Transmission Lines From the Lightning Flashover Standpoint
J. A. Rawls, Virginia Electric and Power Company, P. O. Box 1194, Richmond 9, Va.

General Aspects of Ultrahigh-Frequency Broadcasting
Edward W. Allen, Jr., Federal Communications Commission, Washington 25, D. C.

The Selection and Amplification of Ultrahigh-Frequency Television Signals
(John Waring, W. P. Boothroyd)
W. P. Boothroyd, Philco Corporation, Tioga and "C" Streets, Philadelphia, Pa.

Germanium Phototransistors
John N. Shive, Bell Telephone Laboratories, Murray Hill, N. J.

Zener Breakdown as a Function of Material Resistivity
Baldwin Sawyer, Bell Telephone Laboratories, Murray Hill, N. J.

The Response of Germanium Junction Diodes to Pulse and Sine-Wave Input
(R. G. Shulman, M. E. McMahon)
R. G. Shulman, Hughes Aircraft Company, Florence and Teale Streets, Culver City, Calif.

Power Supply for Resistance Welding Machines—The Power Company's Section
H. Watson Tietze, Public Service Electric and Gas Company, Room 7125, 80 Park Place, Newark, N. J.

Presentation of Section 6—Information for Power Users of AIEE Special Publication S-45—Power Supply for Resistance Welding Machines
W. K. Boice, General Electric Company, 129 Church Street, New Haven, Conn.

The Ferromagnetic Faraday Effect at Microwave Frequencies and Its Applications
C. L. Hogan, Bell Telephone Laboratories, Murray Hill, N. J.

Grain-Oriented Iron-Silicon Alloys—A Flourishing Development
Guerney H. Cole, Sr., Research Laboratories, Armo Steel Corporation, Middletown, Ohio

The Permeability of Silicon-Iron at Very Low Flux Densities
Dr. Eberhard Both, Components and Materials Branch, Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

The Synchronization Problem in Color Television
Donald G. Fink, Director of Research-R, T&A, Philco Corporation, Tioga and "C" Streets, Philadelphia 34, Pa.

Development of Executive Ability
Robert K. Greenleaf, American Telephone and Telegraph Company, 195 Broadway, New York 7, N. Y.

Management Responsibility for Development of Engineers
Francis K. McCune, General Electric Company, 1 River Road, Schenectady, N. Y.

Electronics in the Biomedical Program of the Atomic Energy Commission
Dr. John C. Bugher, Director, Division of Biology and Medicine, United States Atomic Energy Commission, Washington 25, D. C.

A High-Sensitivity Fission Counter
William Baer, Westinghouse Atomic Power Division, P. O. Box 1468, Pittsburgh 30, Pa.

Operatorless Elevators
Sidney J. Clark, Otis Elevator Company, 260—11th Avenue, New York 1, N. Y.

The Widening Field of Moving Stairways
H. C. Hickock, Westinghouse Electric Corporation, 150 Pacific Avenue, Jersey City, N. J.

Safety Aspects of Grounding Versus Insulating—Domestic and Portable Appliances
A. W. Smoot, Underwriters' Laboratories, Inc., 161 Sixth Avenue, New York 13, N. Y.

Hunting Frequencies of Synchronous Motors
Dr. Lloyd J. Money, Hughes Aircraft Company, Building 12, Culver City, Calif.

Program of the Basic Concepts Subcommittee
Victor P. Hessler, University of Illinois, Urbana, Ill.

Work in Progress on the Subject of Electric and Magnetic Units and Magnitudes
J. J. Smith, General Electric Company, 1 River Road, Schenectady, N. Y.

Rationalization and Its Relation to MKS Units
Carl C. Chambers, Moore School of Electrical Engineering, University of Pennsylvania, 200 South 33d Street, Philadelphia 4, Pa.

Electrification—Its Generation and Behavior—In Hospital Operating Rooms
Robin Beach, Robin Beach Engineers Associated, 32 Court Street, Brooklyn, N. Y.

Explosion Hazards in the Operating Room
Dr. Carl W. Walter, Peter Bent Brigham Hospital, 721 Huntington Avenue, Boston 15, Mass.

A Negative-Phase-Sequence Overcurrent Relay for Generator Protection
(W. C. Morris, L. E. Goff)
L. E. Goff, General Electric Company, 6901 Elmwood Avenue, Philadelphia 42, Pa.

The Application of Selenium Rectifiers to Power Supplies for Electrical Precipitation
(R. G. Schlawin, P. V. Hahn)
Peter V. Hahn, General Electric Company, 920 Western Avenue, Lynn, Mass.

Test Code for Evaluation of Systems of Insulating Materials for Random Wound Electric Machinery
(P. L. Alger)
R. Harrington, Thomson Laboratory, General Electric Company, River Works, Lynn, Mass.

A Method of Evaluating Insulation Systems in Motors
(C. B. Leape, J. McDonald, G. P. Gibson)
Jack McDonald, Westinghouse Electric Corporation, Braddock Avenue, East Pittsburgh, Pa.

Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue
C. J. Herman, General Electric Company, 1635 Broadway, Fort Wayne, Ind.

Progress Report on Functional Evaluation of Motor Insulation Systems
R. Harrington, General Electric Company, Thomson Laboratories, 920 Western Avenue, West Lynn 3, Mass.

Leakage-Voltage Characteristics of Insulation Related to D-C Dielectric Strength
(J. S. Johnson, J. W. Clokey)
J. S. Johnson, Westinghouse Electric Corporation, Generator Engineering Department, 5-N, 700 Braddock Avenue, East Pittsburgh, Pa.

Conelrad Number 84316
Ralph J. Renton, Federal Communications Commission, Washington 25, D. C.

New Jersey Turnpike—A Unique Highway Communication System
(P. F. Godley, D. R. Marsh, J. R. Neubauer)
J. R. Neubauer, RCA Victor, Building 10-5, Camden, N. J.

An Application of Magnetic Amplifier Circuits to Perform Multiplication and Other Analytical Operations
(L. A. Finzi, R. A. Mathias)
Professor L. A. Finzi, Carnegie Institute of Technology, Pittsburgh 13, Pa.

Matching Motor Characteristics to the Characteristics of the Driven Auxiliary Equipment
E. Ensign Edgell, Westinghouse Electric Corporation, Motor Division, Genesee Street, Cheektowago, N. Y.

Progress in the Use of Weather-Protected Motors
R. B. Schultz, Elliott Company, Ridgway, Pa.

The Effect of Purchaser's Specifications and Industry Standards on Induction-Motor Design
W. M. Schweder, Schenectady Induction Motor Engineering, Schenectady 5, N. Y.

Effects of Atmospheric Conditions on Induction-Motor Enclosure and Design
(M. R. Lory, J. F. Heidbreder)
J. F. Heidbreder, Westinghouse Electric Corporation, A-C Generator Department, East Pittsburgh, Pa.

Impulse Ionization and Breakdown of Liquid Dielectrics
(G. M. L. Sommerman, C. J. Bute, E. L. C. Larson)
G. M. L. Sommerman, Battelle Memorial Institute, 505 King Avenue, Columbus 1, Ohio

Effect of Corona Discharges on Electric Breakdown of Solid Insulation
(T. W. Dakin, C. N. Works)
T. W. Dakin, Westinghouse Research Laboratory, East Pittsburgh, Pa.

On the Design and Measurement of Hydrogen Thyratron Modulator Characteristics
(Seymour Goldberg, K. J. Germeshausen)
K. J. Germeshausen, Edgerton, Germeshausen and Grier, Inc., 160 Brookline Avenue, Boston 15, Mass.

Some Factors Involved in Breakdown, Conduction, and Recovery of the Hydrogen Thyratron
(Professor William Allis, Dr. Stuart T. Martin, K. J. Germeshausen)
K. J. Germeshausen, Edgerton, Germeshausen and Grier, Inc., 160 Brookline Avenue, Boston 15, Mass.

Fast-Response High-Current Thyratron Power Supplies for Inductive Loads
James H. Burnett, Electrons, Incorporated, 127 Sussex Avenue, Newark 4, N. J.

Experimental Studies and Applications of Explosive Pressures Produced by Sparks in Confined Channels
(H. C. Early, W. G. Dow)
H. C. Early, Department of Electrical Engineering, University of Michigan, Ann Arbor, Mich.

A New Coaxial Blade Transfer Switch
(S. C. Killian, N. Polgov)
R. Stevens, Delta-Star Electric Company, 2437 Fulton Street, Chicago 12, Ill.

Interim Report on Bushing Standardization
(NEMA Joint Committee on Outdoor Apparatus Bushings)
G. W. Clothier, Allis-Chalmers Manufacturing Company, Transformer Section, Milwaukee, Wis.

Dielectric Breakdown of Sulfur Hexafluoride in Nonuniform Fields
(C. N. Works, T. W. Dakin)
C. N. Works, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Some Recent Developments in Potentiometer Pickups
(V. C. Westcott)
H. A. Morrison, Jr., Trans-Sonics, Inc., Bedford, Mass.

An Automatic Inventory System for Air Travel Reservation
(M. L. Haselton, E. L. Schmidt)
E. L. Schmidt, Associate Director, The Teleregister Corporation, 157 Chambers Street, New York 7, N. Y.

Univac on Election Night
Arthur F. Draper, Remington Rand Inc., Laboratory of Advanced Research, Wilson Avenue, South Norwalk, Conn.

Economics of Boiler-Feed-Pump Drives
(R. W. Ferguson, E. W. DuBois)
E. W. DuBois, Westinghouse Electric Corporation, 40 Wall Street, Room 2323, New York 5, N. Y.

New High-Temperature Silicone Resins
J. F. Dexter, Dow Corning Corporation, Midland, Mich.

Tailoring of Silicone Rubber to Meet Electrical Requirements
(M. G. Noble, D. A. Lupfer)
Robert Treat, Jr., General Electric Company, Waterford, N. Y.

Applications of Teflon in the Electrical Industry
Berten E. Ely, Jr., Polychem Department, E. I. duPont de Nemours and Company, duPont Building, Wilmington, Del.

The Electrical Decomposition of Sulfur Hexafluoride
(D. Edelson, C. A. Bieling, G. T. Kohman)
D. Edelson, Bell Telephone Laboratories, Murray Hill, N. J.

Corona Decomposition of Fluorocarbon Gases
(N. M. Bashara, J. D. LaZerte)
N. M. Bashara, Minnesota Mining and Manufacturing Company, 367 Grove Street, St. Paul 1, Minn.

Control of Air Ion Density in Homes
(H. H. Skilling, J. C. Beckett)
John C. Beckett, Wesix Electric Heater Company, 390 First Street, San Francisco, Calif.

Construction, Components, and Control of Packaged Adjustable-Voltage Drives
Gerald Secor, Cutler-Hammer, Inc., 315 North 12th Street, Milwaukee, Wis.

The Electronic Packaged Drive
Ernest F. Kubler, General Electric Company, Schenectady, N. Y.

Packaged-Drive Design Problems
E. H. Vedder, Westinghouse Electric Corporation, Box 2025, Buffalo, N. Y.

1-Kw Tetrode for Ultrahigh-Frequency Transmitters
(W. P. Bennett, H. F. Kozanowski)
Radio Corporation of America, Commercial Engineering Department, RCA Victor Division, Harrison, N. J.

Picture Tube Focusing Systems
William A. Dickinson, Sylvania Electric Company, Seneca Falls, N. Y.

Comparison of Analogue and Digital Methods in Solving the Relativistic Wave Equation
Keith R. Symon, Department of Physics, Wayne University, Detroit 1, Mich.

Some Techniques and Problems in the Application of Analogue Computers to Aircraft Stability Studies
(D. J. Povejsil, R. D. Bidne, R. A. Manske, A. W. McCourt)
A. W. McCourt, Westinghouse Electric Corporation, Friendship International Airport, Baltimore 3, Md.

Influence of Digital Computers on the Optical Lens Problem
(Saul Rosen, Cornelius Eldert, Morris Rubinoff)
Dr. Saul Rosen, University of Pennsylvania, Moore School of Electrical Engineering, 200 South 33d Street, Philadelphia 4, Pa.

Load-Controlling System for Large and Quick Load Changes
A. F. Schwendner, Westinghouse Electric Corporation, Lester Branch Post Office, Philadelphia 13, Pa.

Is the European Circuit Breaker Rating System Really More Conservative Than the American?
R. C. Van Sickle, Westinghouse Electric Corporation, Circuit Breaker Engineering-8N, East Pittsburgh, Pa.

Considerations in the Operation of Outdoor Switching Equipment Under Low Ambient Temperature Conditions
(A. H. Powell, E. B. Rietz)
W. N. Gittings, General Electric Company, 6901 Elmwood Avenue, Philadelphia 42, Pa.

Analysis of Induction Tachometer Generators
(Kurt Burian)
C. Larson, G-M Laboratories Inc., 4300 North Knox Avenue, Chicago 45, Ill.

Nondestructive Sensing of Magnetic Cores
D. A. Buck and W. I. Frank, Massachusetts Institute of Technology, Digital Computer Laboratory, 68 Albany Street, Cambridge, Mass.

Complexity in United States Air Force Electronic Equipment
R. J. Nordlund, Armament Laboratory WADC, Wright-Patterson Air Force Base, Dayton, Ohio

Operating Characteristics of Driving Elements in Regulated Systems
W. O. Osbon, Westinghouse Research Laboratories, East Pittsburgh, Pa.

Importance of Corrosion and Cathodic Protection in Modern Engineering
(L. P. Sudrabin)
F. P. MacDonald, Electro Rust-Proofing Corporation, 1 Main Street, Belleville, N. J.

Factors Affecting the Choice of Instruments for Corrosion Measurements
H. N. Hayward, University of Illinois, Electrical Engineering Department, Urbana, Ill.

Cathodic Protection of Electric Substations and Power Plants
E. H. Thalmann, Ebasco Services, Inc., 2 Rector Street, New York 6, N. Y.

Methods of Electrolysis Potential Control on Underground Cable Systems
F. E. Kulman, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.

System Recovery Voltage and Short-Circuit Duty for High-Voltage Circuit Breakers
(I. B. Johnson, A. J. Schultz, W. F. Skeats)
I. B. Johnson, General Electric Company, Building Number 2, Room 627, 1 River Road, Schenectady, N. Y.

Equations for Determining Current Distribution Among the Conductors of Busses Comprised of Double-Channel Conductors
(C. M. Siegel, T. J. Higgins)
Clifford M. Siegel, Department of Engineering, University of Virginia, Charlottesville, Va.

A Switching System for Dispatcher Test Wires
Philip R. Easterlin, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y.

History and Development of the Magnesium Industry
F. M. Baxandall, The Dow Chemical Company, Midland, Mich.

History and Development of Major Electrolytic Processes
W. E. Gutzwiller, Allis-Chalmers Manufacturing Company, Hawley Works, Hawley Road, Milwaukee, Wis.

Aspects of an Insurance Program for D-C Conversion or Generating Equipment
J. N. Fogg, Power Superintendent, Ethyl Corporation, P. O. Box 341, Baton Rouge, La.

A supplemental list of available conference papers from the Winter General Meeting is scheduled for the April issue of *Electrical Engineering*.

AIEE Will Sponsor Sessions at Chicago Meeting of American Power Conference

The second annual meeting of the American Power Conference will be held March 25–27, 1953, at the Sherman Hotel in Chicago, Ill.

The Power Conference will be sponsored by the Illinois Institute of Technology in co-operation with nine universities and ten local and national engineering societies including the AIEE.

The purpose of the conference is to provide a forum for the exchange of information in the fields of power generation, transmission, distribution, and utilization. All persons interested are invited to attend. For further information write to E. R. Whitehead, Secretary, American Power Conference, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Tentative Program

American Power Conference, March 25-27

Wednesday, March 25

9:00 a.m. Registration, Sherman Hotel

10:00 a.m. Opening Meeting

Chairman: H. D. Maxon, Commonwealth Edison Company

Address of Welcome. Charles Y. Freeman, Chairman of the Board, Commonwealth Edison Company

Address. W. A. Lewis, Dean of the Graduate School, Illinois Institute of Technology. "The American Power Conference—Its Aims and Purpose"

Address. The Honorable Douglas McKay, Secretary of the Interior, Washington, D. C.

12:15 p.m. American Power Conference Luncheon

Sponsored by American Society of Mechanical Engineers

2:00 p.m. Large Steam Generators

Chairman: H. L. Solberg, Purdue University

3,000,000-Kw Operating Experience With Modern Reheat. *Otto de Lorenzi*, Combustion Engineering-Superheater, Inc.

Trends Indicating Possibilities in Future Boiler Designs. *G. W. Kessler*, The Babcock and Wilcox Company

2:00–5:00 p.m. Symposium on Water Problems of American Industry

Chairman: Philip Swain, Editor, *Power*

Panel Discussion on Water Resources of America. *J. C. McCabe, L. N. Rowley, B. G. A. Skrotzki, Power* Magazine

Waste Disposal and Stream Pollution From the Point of View of Industry. *H. W. Gehm*, National Council for Stream Improvement, Inc.

Problems of Waste Disposal and Stream Pollution From the Point of View of the Public. *E. J. Cleary*, Ohio River Valley Water Sanitation Commission

2:00 p.m. Electric Power Transmission

Sponsored by Power Group, AIEE Chicago Section

Chairman: W. E. Keefe, Chairman, Power Group, AIEE Chicago Section

High-Voltage Power Transmission in the Pacific Northwest. *S. E. Schultz*, Bonneville Power Administration

Full-Scale Structure Tests of 230-Kv "H" Frames. *W. A. Schulz*, Public Service Company of Indiana, Inc.

2:00 p.m. Problems of Fuel Conversion

Sponsored by National Association of Power Engineers

3:30 p.m. Steam Generator Controls

Sponsored by Power and Fuels Division, ASME Chicago Section

Chairman: J. G. Eilering, Chairman, Power and Fuels Division, ASME Chicago Section

Some Control Circuits for Use of Multiple Fuel Firing on Boilers. *H. Ziebolz*, Askania Regulator Company

Trends in Combustion and Steam Temperature Control. *P. S. Dickey*, Bailey Meter Company

3:30 p.m. Electrical Distribution

Chairman: M. A. Faucett, University of Illinois

Double Contingency Outages in Secondary Network Systems. *N. M. Neagle, D. R. Nelson*, General Electric Company

Overhead Primary and Secondary Distribution Networks. *H. G. Barnett, D. F. Shankle*, Westinghouse Electric Corporation

3:30 p.m. Personnel Training

Sponsored by National Association of Power Engineers

7:00–10:00 p.m. Forum—The Industrial Use of Atomic Energy

Sponsored and arranged by the Industry Committee

Chairman: Louis C. McCabe, Chief, Fuels and Explosives Division, Washington, D. C.

The Atomic Energy Commission's Appraisal. *G. E. Dean*, Atomic Energy Commission

Engineering and Technical Problems. *Walter Zinn*, Argonne National Laboratory

Economic Evaluation. *W. L. Cisler*, Detroit Edison Company

Changes in the Atomic Energy Act. *O. M. Ruebhausen*, New York Bar Association Committee on Atomi Energy

Current Legislation. Chairman, Congressional Join Committee on Atomic Energy

Summary. *Murray Joslin*, Commonwealth Edisor Company

Thursday, March 26

9:00 a.m.–12:00 noon. Symposium or Large Steam Turbines

Chairman: B. G. Elliott, University of Wisconsin

Development of the 3,600-Rpm Turbine. *H. R Reese*, Westinghouse Electric Corporation

Developments in Large Steam Turbines. *Car Schabtach*, General Electric Company

9:00 a.m. Planning and Economi Analysis

Chairman: J. A. M. Lyon, Northwestern University

A Technique of System Economic Analysis Useful ir Long-Range Planning. *H. E. Campbell, E. H. Reilly Jr.*, General Electric Company

A New Method of Area-wide Generation Control fo Interconnected Power Systems, *N. Cohn*, Leeds anc Northrup Company

9:00 a.m. Hydroelectric Power I

Sponsored by ASCE Illinois Section

Chairman: Frank W. Edwards, President, ASCE Illinois Section

Falcon Dam and Power Plants. *J. B. White*, International Boundary and Water Commission, Unitec States and Mexico

The Guayabo Hydroelectric Power Development *E. M. Fucik*, Harza Engineering Company

9:00 a.m. Water Resources and Wate Treatment for Small Plants

Chairman: M. D. Baker, West Penn Power Company

An Evaluation of Our Water Resources. *A. M Buswell*, Illinois State Water Survey

Alkalinity Reduction by an Approved Process o Anion Exchange. *A. E. Kittredge*, American Wate Softening Company

10:30 a.m. Industrial Power (Electric)

Chairman: A. M. Hopkin, Chairman, Industria Group, AIEE Chicago Section

Voltage Flicker From Loads on Electric System *Marvin Fisher, Jr.*, University of Illinois

Arc Furnaces—Light Flicker and Supply System *D. F. Shankle*, Westinghouse Electric Corporation

10:30 a.m. Hydroelectric Power II

Chairman: J. G. Tarboux, University of Michigan

The Generation and Use of Niagara and St. Lawrenc Power in the Province of Ontario. *R. L. Hearn* Hydro-Electric Power Commission of Ontario

The American Development of Power on the Niagar River. *H. I. Howell*, Niagara Mohawk Power Corporation

10:30 a.m. Heat Pump Research anc Applications

Chairman: R. G. Owens, Illinois Institute of Technology

Operation and Performance of New University c Kentucky Earth Heat Pump. *E. B. Penrod*, University of Kentucky

The Design and Manufacture of the Heat Pum Water Heater. *T. A. Hogdon*, Harvey Whipple, Inc.

12:15 p.m. American Power Conferenc Luncheon

Sponsored by the AIEE

Speaker: B. L. England, President, Edison Electri Institute

2:00p.m. Symposium on Large Electric Generators

Chairman: W. A. Lewis, Illinois Institute of Technology

Desirable Characteristics for Large Generators. *J. B. McClure, C. E. Kilbourne*, General Electric Company

Inner-Cooling of Turbine-Generators. Westinghouse Electric Corporation

Supercharged Cooling for Large Turbines. *W. L. Ringland, L. T. Rosenberg*, Allis-Chalmers Manufacturing Company

Operating Experience With Large Generating Units. *R. P. Liversidge*, Philadelphia Electric Company

2:00 p.m. Fuels and Combustion

Chairman: E. C. Lundquist, State University of Iowa

Preparation and Combustion of Jet-Pulverized Coal. *C. G. Von Fredersdorff*, Institute of Gas Technology

Burning of Paper-Mill Waste Liquor. *J. E. Hoest*, National Container Corporation of Wisconsin

2:00 p.m. Heating of Modern Homes

Recent Advances in the Art of Heating Homes. *R. W. Roose*, University of Illinois

Load-Limiting Controls for Electric House Heating. *W. F. Friend*, Ebasco Services, Inc.

2:00–5:00 p.m. Symposium on Industrial and Institutional Plant Operation

Sponsored by National Association of Power Engineers

3:30 p.m. Solid and Liquid Fuels

Chairman: Martin Elliott, Illinois Institute of Technology

Long-Range Outlook for Liquid Fuels in America. *Eugene Ayres*, Gulf Research and Development Company

Use of Low Rank Fuels in the United States. *L. C. McCabe*, United States Bureau of Mines

3:30 p.m. Control of Iron Pickup by Boiler Feedwater

Chairman: R. C. Adams, United States Naval Engineering Experiment Station

Use of Amines for Control of Iron Pickup. *H. J. Guillory*, Central Louisiana Electric Company

Prevention of Metal Losses in the Wet Steam Areas of Steam Turbines. *F. L. Archibald, J. W. Purssell*, Boston Edison Company; *F. G. Straub*, University of Illinois

6:45 p.m. All Engineers Dinner

Presiding: J. T. Rettaliata, Illinois Institute of Technology

Friday, March 27

9:00 a.m. Residential Air Conditioning

Chairman: L. G. Miller, Michigan State College

Promoting the Installation of Residential Heat Pumps. *G. S. Whitlow*, Union Electric Company

New Application Techniques Improve Residential Air Conditioning. *E. P. Palmatier*, Carrier Corporation

9:00 a.m. General Interest Session

Chairman: G. Ross Henninger, Iowa State College

Are Federal Power Practices Sound National Policy? *E. Robert de Luccia*, Pacific Power and Light Company

The Materials Situation as Related to the Power Industry. *J. F. Moore*, Ebasco Services, Inc.

9:00 a.m. Characteristics of Ion Exchange Resins

Sponsored by Water Technology Division, ASME Chicago Section

Chairman: Louis Wirth, Chairman, Water Technology Division, ASME Chicago Section

Acid Regeneration of Cation Exchangers. *F. A. Lindsay*, National Aluminate Corporation

Factors Influencing the Operation of Anion Exchange Resins. *F. X. McGarvey, J. Thompson*, Rohm and Haas Company

Characteristics of Mixed Bed and 2-Step Ion Exchangers. *M. E. Gilwood, C. Calmon*, The Permutit Company

9:00 a.m. Diesel Engines

Chairman: W. P. Green, Armour Research Foundation

10:30 a.m. Residential and Commercial Heat Pumps

Chairman: W. T. Reace, Commonwealth Edison Company

The Air-to-Air Residential Heat Pump. *G. L. Biehn*, Westinghouse Electric Corporation

Commercial Year-Round Air Conditioning With the Heat Pump. *Philip Sporn, E. R. Ambrose*, American Gas and Electric Service Corporation

10:30 a.m. Electronics Applications

Chairman: G. E. Foster, Chairman, Electronics Group, AIEE Chicago Section

Use of Carrier Spectrum. *T. A. Cramer*, General Electric Company

Survey of Power Plant Electronics and Resulting Maintenance. *Harold Garton*, Commonwealth Edison Company

10:30 a.m. Gas Turbine Combustion Problems

Chairman: N. A. Hall, University of Minnesota

Combustion in Gas Turbines. *H. R. Hazard*, Battelle Memorial Institute

Corrosion Aspects of Bunker "C" Combustion in Gas Turbines. *B. O. Buckland, G. M. Gardiner*, General Electric Company

12:15 p.m. American Power Conference Luncheon

Sponsored by Western Society of Engineers

Chairman: O. W. Eshbach, President, Western Society of Engineers

Speaker: E. B. Newill, General Motors Corporation

2:00–5:00 p.m. Symposium on Gas Turbines

Chairman: J. I. Yellott, Director of Research, Locomotive Development Committee

A Regenerative Gas Turbine-Generator for Central Station Service. *H. C. Davis*, Texas Power and Light Company; *B. O. Buckland*, General Electric Company

Development and Application of Gas Turbines for the Oil and Gas Industry. *T. P. Latimer, J. K. Hubbard*, Clark Brothers Company

Turbo-Jet Aircraft Engines. *Dimitrius Gerdan*, General Motors Corporation

2:00–5:00 p.m. Economics of Evaporation and Demineralization

Chairman: R. G. Gall, Chairman, Power Station Subcommittee, Prime Movers Committee, Edison Electric Institute; American Gas and Electric Company

Economics, the Key to Evaporation Versus Demineralization for Makeup in High-Pressure Steam Power Plants. *E. B. Morris, C. E. Brune*, American Gas and Electric Corporation

Evaporation for Treatment of Makeup. *A. M. Impagliazzo*, Griscom-Russell Company

Performance of a Complete Demineralization Process for High-Pressure Boiler Makeup Water. *A. B. Sisson*, Public Service Company of Northern Illinois

2:00–5:00 p.m. Symposium on Network Analyzers

Chairman: E. T. B. Gross, Illinois Institute of Technology

Participants:
G. W. Bills, Bonneville Power Administration
W. B. Boast, Iowa State College
R. D. Goodrich, United States Bureau of Reclamation
L. M. Haupt, Texas Agricultural and Mechanical College
J. B. Ward, Purdue University
G. P. Wilson, Jackson and Moreland Engineers

High-Frequency Measurements Discussed at Joint Conference in Washington, D. C.

The third Conference on High-Frequency Measurements was held in Washington, D. C., January 14–16, 1953, in the auditorium of the Department of the Interior. The sponsors were the AIEE, Institute of Radio Engineers (IRE), and the National Bureau of Standards (NBS). Twenty-seven technical papers were presented at the four sessions and two demonstration lectures were given at the Thursday evening joint meeting of the Washington Sections of the AIEE and the IRE. More than 700 engineers and guests attended the sessions and the luncheon on Thursday at the Hotel Statler, the conference headquarters.

Harold Lyons, NBS, presided at the opening session and introduced Dr. A. V. Astin, Director, NBS, who welcomed the members to the conference and Washington. This first session was devoted to papers dealing with the measurement of frequency, wavelength, and time. Dr. L. Essen, National Physical Laboratory, Teddington, England, presented the results of a long series of his experiments determining the velocity of electromagnetic waves and the refractive indexes of gases in which he used the cavity resonator and the hybrid T junction which are respectively the analogues of the Fabry-Perot and the Michelson interferometers. Dr. Essen's value of this velocity using the cavity-resonator method was $C=299{,}792.5\pm1.0$ kilometer per second. The second paper also dealt with this same measurement of velocity of electromagnetic waves, a report being given by Dr. K. Bol of the work at Stanford University using a cylindrical cavity resonator in the TE_{012} and TE_{021} modes at frequencies near 3,000 megacycles. His result was $C=299{,}789.4\pm0.3$ kilometer per second.

The other five papers presented at this session dealt with the measurement of resonant cavity characteristics, microwave frequency calibration procedures, time counters, and an electronic chronograph developed at NBS which can be read to about 0.02 millisecond.

Six papers were presented at the session devoted to the measurement of power and attenuation, over which E. W. Houghton, Bell Telephone Laboratories, presided. This session was followed by the luncheon at the Hotel Statler, at which E. P. Felch, Chairman, Joint AIEE-IRE Committee on High-Frequency Measurements, was toastmaster.

After introducing the honored guests, among whom were AIEE Past-President E. S. Lee representing AIEE President D. A. Quarles; IRE President J. W. McRae; Dr. Ralph Bennett, Director, Naval Ordnance Laboratory; and Dr. A. V. Astin, Mr. Felch introduced the guest speaker, Dr. Alan T. Waterman, Director, National Science Foundation.

Dr. Waterman first outlined the functions of the Foundation; they are to develop a national policy for basic research; to award contracts, scholarships, and fellowships; and to maintain a roster of scientists. About 200 grants for research have been awarded for broad scientific research, not just engineering, to institutions all over the United States. In 1952 help was provided by the Federal Government to nonprofit institutions for researches in the physical sciences, biological and agricultural, and the social sciences, the maximum support being given by the Department of Defense followed by the Atomic Energy Commission.

The speaker stated that the manpower situation is acute as estimates from the colleges indicate that in 1954 the number of graduates will be about one-third of what it was in 1950. He stressed that secondary-school teachers apparently are not urging their pupils to attend college as much as they should.

The National Science Foundation wants to aid studies in broad basic research along engineering lines and will support them financially up to a certain limit. The institutions where these studies are being made should be willing to assume their portion of the financial burden and not to look to the Federal Government for everything.

The luncheon was followed by four well-attended inspection trips; these were to the National Bureau of Standards, Naval Observatory, Naval Ordnance Laboratory, and the Naval Research Laboratory.

The demonstration lectures in the Interior Department auditorium were given Thursday evening by A. G. Fox and R. L. Wallace, Jr., both of the Bell Telephone Laboratories. The first speaker told about and demonstrated microwave travel along dielectric rods and in ferromagnetic media and Mr. Wallace described a new transistor for use in the high-frequency region. F. Hamburger, Jr., Chairman, AIEE Group, Joint AIEE-IRE Committee on High-Frequency Measurements, presided over the session.

J. W. Kearney, Airborne Instruments Laboratory, presided at the Friday morning session, which was devoted to the measurement of transmission and reception, and F. J. Gaffney, Polytechnic Research and Development Company, was chairman of the afternoon session devoted to impedance measurements.

Harold Lyons and R. G. Fellers were cochairmen of the Local Arrangements Committee; F. Hamburger, Jr., Technical Program Committee; I. G. Easton, publicity; and W. F. Snyder was conference treasurer.

Shown here conferring on plans for the coming Southern District Meeting in Louisville, Ky., are, left to right: S. T. Fife, Student Activities; J. F. Gregory, Registration; E. S. Lammers, Jr., Vice-President, District 4; J. D. Warren, Secretary; J. G. Lips, Vice-Chairman; R. D. Spalding, Transportation; L. G. Weiser, Sports; W. J. Ryan, Finance; E. A. Zuercher, Jr., L. H. Gottliebsen, Representatives from Domestic Appliances Subcommittee; J. D. Caudill, Entertainment; W. B. Watkins, Inspection Trips; M. G. Northrop, General Chairman. Committee members not present: H. T. Smith, Hotels and Meeting Rooms; J. M. Houchens, Printing; O. W. Towner, Publicity; T. W. Talcott, Meeting and Equipment

Southern District Meeting Scheduled for Louisville

"Industry Moves South" will be the theme of this year's AIEE Southern District Meeting, which will be held concurrently with the Student Branch Meeting at Louisville, Ky., April 22–24. Headquarters will be at the Hotel Seelbach. The opening general session is scheduled for Wednesday at 10 a.m.

Four technical sessions are planned for the meeting and it is expected that several groups will be meeting during each session. Of particular interest should be the appliance session to be sponsored by the Committee on Domestic and Commercial Applications of the General Applications Division.

Inspection trips are sheduled to observe manufacturing facilities in such industries as air-cleaning equipment, electrostatic precipitation, domestic electric appliances, high-frequency dielectric heating, modern foundry and forging, newspaper and color printing, tobacco processing, cigarettes, and distillery operations. In addition, sightseeing tours are planned through Churchill Downs, historic Cave Hill Cemetery, the large city parks, the Ohio River front, University of Louisville, and shopping centers, as well as an all-day trip to Mammoth Cave.

A full program of entertainment will be provided for the ladies; special tours will include a furniture manufacturing plant and the Colgate-Palmolive-Peet plant.

On Wednesday evening, entertainment and a social hour are scheduled for all, as guests of the Southern District. A luncheon for the Student Counselors will be held on Thursday at noon, and on Thursday evening there will be a banquet and dance.

For those members who are interested in sports, arrangements can be made for golf, tennis, boating, or horseback riding at any of several parks or clubs.

Members planning to attend the Southern District Meeting should make reservations by filling in and mailing the advance registration and hotel reservation card as soon as it is received. Special low-cost accommodations will be available for a limited number of students at the Seelbach Hotel.

Official Nominees Announced for 1953 AIEE National Election

Elgin B. Robertson, President, Elgin B. Robertson, Inc., Dallas, Tex., was nominated for the AIEE presidency by the Nominating Committee at its meeting held in New York, N. Y., January 21, 1953. Others named for election to Institute offices for terms beginning August 1, 1953, are

For Vice-President:

Walter B. Morton, Station Electrical Engineer, Pennsylvania Power and Light Company, Allentown, Pa. (District 2)

C. P. Almon, Jr., Chief, Power System Operations Division, Tennessee Valley Authority, Chattanooga, Tenn. (District 4)

A. S. Anderson, General Electric Company, Denver, Colo. (District 6)

George C. Tenney, Editor, *Electrical West*, McGraw-Hill Company, Inc., San Francisco, Calif. (District 8)

G. D. Floyd, System Planning Engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada (District 10)

For Directors:

Donald I. Cone, Transmission and Protection Engineer, Pacific Telephone and Telegraph Company, San Francisco, Calif

T. M. Linville, Assistant to Engineering Manager, Large Apparatus Department, General Electric Company, Schenectady, N. Y.

E. W. Seeger, Vice-President in Charge of Development and Assistant Secretary, Cutler-Hammer, Inc., Milwaukee, Wis.

For Treasurer:

Walter J. Barrett, Electrical Co-ordination Engineer, New Jersey Bell Telephone Company, Newark, N. J.

The Nominating Committee, in accordance with the Constitution and Bylaws consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution: Section 32. Independent nominations may be made by a petition of twenty-five (25) or more corporate members sent to the Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws: Section 24. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 32 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the Secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

A list of members of the Nominating Committee appeared in the February issue of *Electrical Engineering*, page 171.

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

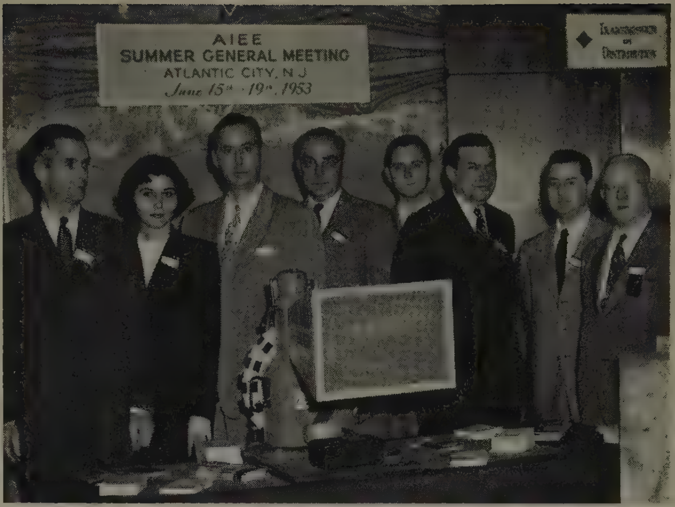
Atlantic City Chosen as Summer Meeting Site

Plans for the AIEE Summer General Meeting, which will be held this year in Atlantic City, N. J., June 15–19, at Chalfonte-Haddon Hall, are rapidly developing. Judging by the interest shown in the promotional material displayed at the recent Winter General Meeting in New York City, a large number of members already are making plans to attend, and the AIEE Philadelphia Section, which will be host for the occasion, anticipates a successful meeting.

An outstanding technical program is assured and it is expected that many members will incorporate attendance at the Summer General Meeting with their vacation plans. Atlantic City is particularly well equipped to accommodate large numbers of people. Hotel facilities are unequalled. In addition to the many planned activities, this famed seashore resort offers fishing, boating, and bathing at beaches among America's finest.

Special events are being scheduled for the ladies and will include luncheons, fashion shows, and sightseeing trips, as well as a moonlight cruise for all. Evening entertainment is being planned on a family basis and a special dinner and show will be held in place of the customary smoker.

Members desiring more detailed information on any feature of the Summer General Meeting are invited to correspond with the Philadelphia Section: L. R. Gaty, Chairman; Philadelphia Electric Company, 1060 Chestnut Street, Philadelphia 5, Pa.



Members of the General Committee for the coming Summer General Meeting in Atlantic City, N. J., grouped around a stand at the Winter General Meeting in New York promoting their meeting. Left to right: L. R. Gaty, chairman of the meeting and chairman of the AIEE Philadelphia Section; Miss Lee Schneider of Atlantic City, who was in charge of the booth; M. L. Stoughton, publicity chairman; William Henn; Lee Nonemaker; J. B. Harris; E. F. Jones; and J. C. Strasbourger, Vice-President, District 2

North Eastern District Meeting Marks Boston Section's 50th Year

Final arrangements are now being made for what promises to be one of the finest North Eastern District Meetings ever held. The meeting, scheduled for Boston, Mass., April 29–May 1, 1953, has as its theme the celebration of the 50th anniversary of the founding of the AIEE Boston Section. An outstanding program has been planned by members of the Boston Section as hosts for this 3-day commemoration. In addition to the technical sessions, there will be a smoker on Wednesday evening, a general meeting on Thursday morning with two highly renowned speakers, and a dinner-dance on Thursday evening featuring a speaker of national interest. On Friday, emphasis will be on Student activities with separate Student paper meetings.

The general meeting on April 30 will highlight the anniversary and C. A. Powel, past president of the AIEE, will serve as chairman. He will deliver the Professor

Convention Bureau, Boston Chamber of Commerce

The United States Frigate Constitution, which was built in Boston in 1797, is open to the public at Charlestown Navy Yard and can be visited by members attending the North Eastern District Meeting. Popularly known as "Old Ironsides," she was involved in about 40 engagements and never suffered defeat

Elihu Thomson 100th Anniversary Memorial Lecture and will introduce the speakers: Dr. Karl T. Compton, Chairman of the Corporation of Massachusetts Institute of Technology; and Dr. L. R. Hafstad, Director of the Division of Reactor Development, Atomic Energy Commission, who will discuss the social aspects of nuclear science, a timely subject in this age of atomic energy.

General topics covered by the technical sessions will be as follows:

Wednesday morning, April 29
Microwave Relaying
Communication and Transistors
Voltage Regulation

Wednesday afternoon, April 29
Power System Communications
Magnetic Amplifiers

Thursday afternoon, April 30
High-Voltage Transmission Stability and Economy
High-Voltage Distribution
Productive Maintenance for Industry

Friday morning, May 1
Student Papers (two sessions)
Industrial Process Control

Friday morning and afternoon, May 1
Conference sessions on Textile Industry

Several inspection trips of interest to these sessions are being planned.

The ladies have been accorded due recognition in the meeting plans and they will find a centrally located, well-staffed Hospitality Room ready to help with activities. A special tea will be held on Wednesday afternoon and in the evening a Ladies' Dinner with excellent entertainment should find everyone well acquainted and ready to embark on several sightseeing tours on Thursday and Friday to points of interest filled with the tradition of the founding of our country. The ladies, of course, are invited to the main banquet on Thursday evening, and on either Thursday or Friday a "Charm and Fashion Show" will be held.

For those interested in sightseeing, here are a few suggestions: State House, with its "Bulfinch" architecture, Louisberg Square, and the surrounding area of Beacon Hill; Park Street Church on "Fire and Brimstone Corner," Old Granary Burying Ground, and King's Chapel; Bunker Hill Monument on Breed's Hill, site of the Battle of Bunker Hill on June 17, 1775; Boston Navy Yard and United States Frigate *Constitution;* Faneuil Hall, the Market District, and famous Durgin and Park Restaurant, and the Custom House Tower; Lexington and Concord, Mass., home of the "Minute Men" and the first battlegrounds of the American Revolution.

Hotel room reservations will be handled through the Sheraton Plaza Hotel, Boston, Mass., and may be had at the Sheraton Plaza, the Hotel Statler, or the Hotel Lenox. Further information on prices and reservations will appear in the April issue.

AIEE PERSONALITIES.....

F. E. Fairman, Jr. (M '41, F '51), general manager, Transformer and Allied Products Division, General Electric Company, Schenectady, N. Y., has been elected a vice-president of the company. Mr. Fairman is a native of Pittsburgh, Pa., and was graduated from the United States Naval Academy in 1921. He entered the employ of General Electric as a requisition engineer at Baltimore Md., in 1923. He left to join the Pennsylvania Water and Power Company in 1925 and returned to his former position at General Electric later the same year. He served as switchgear specialist, steel mill specialist, and manager of steel mill sales in the Pittsburgh office, transferring to the Switchgear Division at Philadelphia, Pa., in 1933. He became sales manager of the Panel and Equipment Division in 1939 and assistant manager of the Switchgear Division 2 years later. From 1945 to 1949, Mr. Fairman was vice-president of the Food Machinery and Chemical Corporation and general manager of its Peerless Pump Division, San Jose, Calif. He returned to General Electric to become manager of sales for the Transformer and Allied Products Division and in 1950 was named general sales manager of the Large Apparatus Division. He was appointed general manager of the Transformer and Allied Products Division the following year. In 1932 Mr. Fairman received the Charles A. Coffin Award from the General Electric Company for his work with the development of solid block silver-to-silver contacts for air circuit breakers.

C. W. LaPierre (AM '28, M '43), general manager of the Aircraft Gas Turbine Division, General Electric Company, Evendale, Ohio, has been elected a vice-president of the company. Mr. LaPierre, a native of Jackson, Mo., attended the University of Missouri and joined the General Electric Company General Engineering Laboratory in 1924. He was placed in charge of the Electromechanical Division of the laboratory in 1936. A year later he received the Charles A. Coffin Award for developing the photoelectric recorder. He was appointed assistant engineer of the laboratory in 1944. In 1947 Mr. LaPierre became vice-president in charge of engineering for the American Machine and Foundry Company, rejoining General Electric in 1949 as assistant manager of the Aircraft Gas Turbine Division. Later that same year he was named manager of the division and then general manager. Mr. LaPierre has served on the AIEE Membership Committee (1944–48).

J. D. Wright (AM '36, M '43), assistant manager, Industry Engineering and Sales Department, General Electric Company, Schenectady, N. Y., retired October 31, 1952. A native of Baraboo, Wis., Mr. Wright was graduated from the University of Wisconsin in 1909 with a bachelor of science degree in electrical engineering. He joined General Electric that same year as a student engineer and in 1910 was assigned to the Industrial Control Engineering Department. Transferred to the steel mill section of the Power and Mining Engineering Department in 1915, Mr. Wright became head of that section in 1922. He was appointed assistant engineer of the Industrial Engineering Department in 1930. Six years later, he was named assistant manager of the Industrial Department, and became manager of the Industrial Engineering Divisions in 1940. In 1950 Mr. Wright assumed the position of assistant manager of the Industry Engineering and Sales Department, the post he held at the time of his retirement. Mr. Wright is a member of the Association of Iron and Steel Engineers and the American Iron and Steel Institute. An active member of the AIEE, he has served on the following Institute committees: Iron and Steel Industry, Applications to Iron and Steel Production (1918–20, 1922–24, 1924–27, 1928–30); Industrial Power Applications (1938–41, Chairman 1938–40); Technical Program (1938–42); Electric Welding (1940–42, Chairman 1940–42); and Standards (1941–42).

W. D. Steele (AM '00, Member for Life), president, Benjamin Electric Manufacturing Company, Des Plaines, Ill., received the 60-year National Electrical Manufacturers Association Certificate at the 26th Annual Meeting of the Association on November 12, 1952. This certificate, which signifies 60 years of continuous and devoted service to the entire electrical industry, is the first such recognition ever given in the history of the National Electrical Manufacturers Association. Mr. Steele was born in Keokuk, Iowa, and was graduated from Iowa State College in 1891. After graduation he was associated with the Cast Iron Pipe Works, Cincinnati, Ohio, then in 1892, joined the Brush Electric Company as an engineer in their Chicago, Ill., office. On January 1, 1894, he became engineer in charge of outside construction for the municipal power plant of the city of Detroit, Mich., later becoming assistant city electrician, and in 1896, city electrician and superintendent in charge of the operation of this plant. In 1900, Mr. Steele joined Westinghouse, Church, Kerr and Company, New York, N. Y. He was one of the organizers of Benjamin Electric Manufacturing Company in 1901, but had no active connection with the company until 1907, when he became vice-president in charge of sales and manufacturing activities. Since 1928, he has been president of the company. He has served as a member of the National Electrical Manufacturers Association Board of Governors.

W. T. Rogers (AM '28, M '42), safety consultant, Ebasco Services, Inc., New York, N. Y., has been elected chairman of the Executive Committee, Public Utilities Section of the National Safety Council. Mr. Rogers has the distinction of having been chairman of all three safety committees serving the utility industry—the Accident Prevention Committee of the Edison Electric Institute, the Accident Prevention Committee of the American Gas Association, and the National Safety Council Public Utilities Section. In addition Mr. Rogers serves on the Co-ordinating Committee o the President of the United States' Industria Safety Conference and is managing director of the Inter-American Safety Council. He is a member of the AIEE Committee on Safety (1943–53).

S. H. Webster (M '44), has been appointed sales manager of Aviation Engineering Corporation, Woodside, N. Y. Mr. Webster, a graduate of Northeastern University, was associated with Eclipse-Pioneer Division, Bendix Aviation Corporation, and before that with Eclipse Aviation Corporation for the past 18 years. During this period he worked directly with sales, production, and engineering and for the last 8 years he was manager of the West Coast Sales and Engineering Office. Mr. Webster served as chairman and vice-chairman, Aircraft Division of the Los Angeles Section of the AIEE (1949–50) and as a member of the AIEE Air Transportation Committee (1948–52).

P. J. Kranenburg (AM '38, M '47), chief electrical engineer, Devenco Incorporated, New York, N. Y., has been promoted to director of engineering. Mr. Kranenburg joined Devenco in November 1951. He had been employed previously as an electrical engineer by Ebasco Services, Inc.; Philco Radio and Television Corporation; General Electric Company; and Edward G. Budd Company. He was graduated in 1927 from Iowa State College with a bachelor of science degree. A licensed professional engineer, Mr. Kranenburg is vice-president of the New York Chapter, New York State Society of Professional Engineers, and is a member of Tau Beta Pi, Eta Kappa Nu, Pi Mu Epsilon, and Phi Kappa Phi.

R. L. Halsted (AM '44), district manager, Allis-Chalmers Manufacturing Company, Cleveland, Ohio, has been appointed manager of Allis-Chalmers central region with headquarters in Cleveland. Mr. Halsted has been with Allis-Chalmers since 1935 and manager of its Cleveland district office since 1948. **Joseph Bronaugh** (AM '29, M '37), manager, Miami (Fla.) district, since 1946 succeeds Mr. Halsted as manager of the Cleveland district office. Mr. Bronaugh joined Allis-Chalmers in 1929. He was successively a sales representative in the Richmond (Va.) office and manager of the Norfolk (Va.) office before being named manager at Miami.

T. G. A. Sillers (AM '26, M '43), engineer-in-charge, development switchgear and control sections, Electrical Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been named chief engineer of the switchgear section of the power department. Mr. Sillers entered Allis-Chalmers employ in 1925 following graduation as an electrical engineer from the University of Manitoba. He joined the company's switchgear section in 1926 after completing the graduate training course. Mr. Sillers is a registered professional engineer and has served on the AIEE Transmission and Distribution Committee (1947–48).

J. E. Sheehan (AM '52) has joined the Esso Engineering Department of the Standard Oil Development Company, Linden, N. J. After serving nearly 2 years in the United States Army, Mr. Sheehan attended Syracuse University, from which he received a bachelor of electrical engineering degree, and Carnegie Institute of Technology, from which he received his master of science degree in electrical engineering. He is a member of Tau Beta Pi, Eta Kappa Nu, and Pi Mu Epsilon.

G. W. Hanafee, Jr. (AM '51) and **R. O. Wenz** (AM '51) have been assigned as sales representatives to the Midwest Region of Allis-Chalmers general machinery division. Mr. Hanafee, a graduate electrical engineer of the University of Louisville, has been assigned to Allis-Chalmers Indianapolis, Ind., district office. Mr. Wenz, an electrical engineering graduate of the University of Minnesota, has been assigned to Allis-Chalmers Duluth, Minn., branch office.

David Sarnoff (M '23, F '51), chairman of the board, Radio Corporation of America, New York, N. Y., has been named the first recipient of the newly established Founders Award by the Institute of Radio Engineers. The award was given "for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare."

L. T. Barry (AM '46) has returned to Electric Service Manufacturing Company, Philadelphia, Pa., as manager of the company's Industrial Division after 17 months service as a colonel with the United States Air Force. He was recalled to active duty in May 1951. While with the Air Force, Mr. Barry served as deputy chief of the Aircraft and Equipment Division at Air Material Headquarters, Wright-Patterson Air Base, Ohio.

R. C. Sogge (M '35), manager, Standards Division, Executive Department, General Electric Company, Schenectady, N. Y., has been elected president of the United States National Committee of the International Electrotechnical Commission. Mr. Sogge, formerly vice-president of the United States National Committee, has been with the General Electric Company since 1916. He has served on the AIEE committees on Standards (1947–49) and Safety (1952–53).

B. M. Koetting (AM '52) has been appointed assistant engineer in the motor generator section, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mr. Koetting is a graduate of the University of Wisconsin and is a member of the Engineers' Society of Milwaukee. **S. H. Telander** (AM '51) has been appointed an assistant engineer in the switchgear section of the company. He is a graduate of the University of Minnesota.

L. M. Swenson (AM '41), application engineer, Allis-Chalmers Manufacturing Company, El Paso, Tex., has been named resident representative at Albuquerque, N. Mex. Mr. Swenson came to Allis-Chalmers in 1940 after graduating as an electrical engineer from Kansas State College. He was associated with the firm's motor and generator sales section for 6 years before transferring to El Paso.

L. M. Dearing (M '51), research director, Technicolor Motion Picture Corporation, Hollywood, Calif., has been elected a Governor, West, by the Society of Motion Picture and Television Engineers for a 2-year term. Mr. Dearing has served on the AIEE Instruments and Measurements Committee (1951–52).

G. B. Seaborn, Jr. (AM '51), junior engineer, Product Development Section, Sylvania Electric Products, Inc., Huntington, W. Va., has been appointed to the staff of the Gaseous Diffusion Plant, Oak Ridge, Tenn., operated by Carbide and Carbon Chemicals Company.

H. P. Steele (AM '44), president, in charge of engineering and research, Benjamin Electric Manufacturing Company, Des Plaines, Ill., has been elected a vice-president of the National Electrical Manufacturers Association.

M. P. Hnlicka (M '46), project development engineer, Carthage Hydrocol, Inc., Brownsville, Tex., has joined the staff of the Chemistry Department, National Research Corporation, Cambridge, Mass. Dr. Hnlicka, a native of Prague, Czechoslovakia, received his bachelor degree at the State College for Technical Studies in 1929. In 1932 he was granted his master degree at the Institute of Mechanical and Electrical Engineering of the Technical University of Prague. He received an equivalent of a doctor degree in Power Generation and Distribution in 1935. In 1945 he was employed by the Coal Research Institute to restore production of mines and synthetic motor fuel production plants which had suffered war damage. Later he journeyed to the United States to assist in the re-establishment of scientific and industrial relations with Czechoslovakia by participating in the evaluation of German installations using the Fischer Tropsch reactions. From 1946 to 1948 Dr. Hnlicka was in charge of development at the Czechoslovakian Motor Fuel Works, the project being undertaken in co-operation with Hydrocarbon Research, Inc., New York, N. Y. In May 1948 Dr. Hnlicka and his family escaped to the United States zone of Germany and in March 1949 he arrived in the United States. In April 1949 he joined Carthage Hydrocol, Inc., as process engineer and consultant.

C. R. Kirkbride (AM '48), Greensburg, Pa., has joined Kuhlman Electric Company, Bay City, Mich., as administrative assistant to the director of engineering. Previous to joining Kuhlman, Mr. Kirkbride was employed by the Uptegraff Manufacturing Company, Scottdale, Pa., Penn Electrical Company, Irwin, Pa., and Pennsylvania Transformer Company, Canonsburg. He was graduated from Carnegie Institute of Technology in 1945 with a degree in electrical engineering.

E. R. de Luccia (M '51), manager and chief engineer, Lewis River Project, Pacific Power and Light Company, Portland, Oreg., has become vice-president and chief engineer of the utility. Mr. de Luccia was formerly chief of the Federal Power Commission's bureau of power. He joined the utility in June 1951 to supervise construction of the company's Yale hydroelectric project. Before assuming his new duties, Mr. de Luccia was in charge of the company's Lewis River development program.

OBITUARY

Harold Althouse Dambly (AM '24, M '30, F '42), engineer-in-charge, Testing Division, Philadelphia (Pa.) Electric Company, died January 15, 1953. Mr. Dambly was born in Skippack, Pa., September 13, 1899, and was graduated from Pennsylvania State College in 1921 with a bachelor of science degree in electrical engineering. He received his master of science degree in electrical engineering at Massachusetts Institute of Technology in 1923. An employee of the Philadelphia Electric Company since 1923, Mr. Dambly served during the Second World War as a consultant in shipbuilding for the Office of Production Mobilization in the War Production Board. For 7 years he served as an instructor in electrical engineering in the evening school at the Drexel Institute of Technology, Philadelphia. Mr. Dambly served as vice-president of the Philadelphia Science Council and was a member of the American Society for Testing Materials, the American Forestry Association, the Utilities Technical Committee of Philadelphia, Edison Electric Institute, Bell System Joint Committee, and the Pennsylvania Electric Association. He was a registered professional engineer and a member of the Pennsylvania Society of Professional Engineers and the Engineers' Club of Philadelphia. He was also a member of Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi. Mr. Dambly had been chairman of the Philadelphia Section of the AIEE (1946–47) and had served on the following Institute committees: Sections (1949–53); Board of Examiners (1949–53); and Transmission and Distribution (1944–50).

Robert J. Weber (M '45), assistant district manager, central sales district, Westinghouse Electric Corporation, Pittsburgh, Pa., died December 28, 1952. A veteran of 42 years with Westinghouse, Mr. Weber had been connected with virtually every manufacturing and sales division of the company. In 1946 he was awarded the Westinghouse Order of Merit, highest award granted to Westinghouse employees for outstanding contributions to the electrical industry. Mr. Weber was born in Buffalo, N. Y., May 3, 1894, and joined Westinghouse in 1910. In 1916 he was graduated from Carnegie Institute of Technology with a bachelor of science degree in electrical engineering. In the company's central district sales organization, Mr. Weber had served as central station manager. In 1950, he was appointed to the position of assistant district manager to handle special assignments. Mr. Weber was a member of The American Society of Mechanical Engineers, Illuminating Engineering Society, and the Pennsylvania Electric Association.

Christian Frederick Van Leeuven Weiland (M '24), former chief electrical engineer for Todd Shipyards and Slocum and Fuller, consulting engineers, and associate editor of *Engineering Index*, New York, N. Y., died January 13, 1953. Mr. Weiland was born in Rotterdam, Holland, February 19, 1887, and graduated as an electrical engineer from Bingen on the Rhine in 1910. From 1910 to 1924 he was employed as an engineer for various engineering firms in Germany and Holland. He came to the United States in 1924 and was employed by the Consumer's Power Company, Jackson, Mich., Long Island Electric Light Company, and American Gas and Electric Company, New York, N. Y. From 1929 until 1938 he was associate editor of *Engineering Index* in New York. After a short period as a consulting engineer, he joined Todd Shipyards in 1940 as chief electrical engineer. He retired in July 1952.

William K. Hackmann (AM '34), electrical engineer, Federal Power Commission, Chicago, Ill., died October 22, 1952. Mr. Hackmann was born in St. Charles, Mo., September 30, 1901, and was graduated from the University of Nebraska in 1926 with a bachelor of science degree in electrical engineering. Following his graduation he was employed by the General Electric Company in various positions in Schenectady, N. Y., and Pittsfield, Mass. He joined the Federal Power Commission in 1934 and participated in several power market and rate surveys in Washington, D. C., before being assigned to the Denver, Colo., Regional Office. In 1941 he took military leave to serve as an officer in the United States Army Air Force. He returned to the Commission following the war and had been attached to the Chicago Regional Office since 1946.

Joseph Taylor Thwaites (AM '37, M '44), research director, Canadian Westinghouse Company, Ltd., Hamilton, Ontario, Canada, died January 15, 1953. Mr. Thwaites was born in Bolton, England, March 2, 1901. He was graduated from Queen's University, Kingston, Ontario, in 1925 with a bachelor of science degree in physics. Following 2 years' postgraduate work in electronics, he joined Smart Turner Company, Hamilton, Ontario, as an engineer. He joined Canadian Westinghouse in 1929 as assistant radio engineer and served successively as new apparatus development engineer, section engineer—electronics, and research director. He was a member of the Engineering Institute of Canada and had served on the AIEE Electronics Committee (1943–53, Chairman 1950–53).

John Robinson Anderson (AM '05, Member-for-Life), retired, American Laundry Machine Company, Rochester, N. Y., died December 22, 1952. Mr. Anderson was born in New York, N. Y., January 12, 1879. Mr. Anderson attended Massachusetts Institute of Technology and taught school in Elkton, Md. Between 1907 and 1912, he was assistant chief engineer in charge of experimental work in Thomas Edison's Menlo Park (N. J.) laboratory. During his career in Rochester, Mr. Anderson was employed by Bausch and Lomb Optical Company, Todd Company, Commercial Controls Corporation, and American Laundry Machine Company.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of January 15, 1953, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Braud, H. M., electrical engineer, U. S. Army, Presidio of San Francisco, Calif.
Brunner, H. C., industry engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Combs, A., substation foreman, Kentucky & West Virginia Power Co., Inc., Hazard, Ky.
Eagan, F. E., principal engineer, R. W. Beck & Associates, Seattle, Wash.
Eannarino, S. F., switchboard design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Geiser, K. R., section engineer, General Electric Co., Schenectady, N. Y.
Gillette, R. W., senior engineer, Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Googe, W. J., supervisor, transmission system, Southwestern Gas & Electric Co., Shreveport, La.
Grabbe, G. M., senior project engineer, Allison Div., General Motors Corp., Indianapolis, Ind.
Hacking, *Sir* John, deputy chairman, British Electricity Authority, London, England
Ham, J. M., assoc. professor of electrical engineering, University of Toronto, Ontario, Canada
Holland, C. H., manager, General Electric Co., Riverside, Calif.
Holloway, V. C., electrical engineer, Naval Research Laboratory, Washington, D. C.
James, E. C., maintenance supervisor, Public Service Electric & Gas Co., Sewaren, N. J.
Jenkins, J. E., engineer, Armature Winding Co., Charlotte, N. C.
Levitsky, N. B., general plant superintendent, Tata Hydro-Electric Cos., Ltd., Fort Bombay, India
Lewis, T. H., supervising meter engineer, Hydro-Electric Power Commission of Ontario, London, Ontario, Canada
McPherson, G., Jr., electrical engineer, Battelle Memorial Institute, Columbus, Ohio
Norberg, A. V., consulting electrical engineer, 1341 T St., Sacramento, Calif.
Pask, D. A., resident engineer, British Electricity Authority, Instow, North Devonshire, England
Rochholz, C. A., depreciation engineer, California Electric Co., Riverside, Calif.
Smith, M. C., research engineer, Jet Propulsion Lab., California Institute of Technology, Pasadena, Calif.
Welsh, J. P., research engineer, Cornell Aeronautical Lab., Buffalo, N. Y.
Wurdack, A. C., Jr., section engineer, Line Material Co., Zanesville, Ohio
Zak, S. J., sales engineering manager, John Oster Mfg. Co., Racine, Wis.

25 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before March 25, 1953, or May 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Armstrong, E. H., Columbia University, New York, N. Y.
Bates, A. C., I-T-E Circuit Breaker Co., R. & I. E. Equipment Div., Greensburg, Pa.
Brailsford, F., University of London, London, England
Cox, C. R., Andrew Corporation, Chicago, Ill.
Lang, J. S. (re-election), United Engineers & Constructors, Inc., Philadelphia, Pa.
Schulze, R. C. R. (re-election), Atlantic City Electric Co., Atlantic City, N. J.

6 to grade of Member

OF CURRENT INTEREST

OARAC, New Electronic Computer, Has One of Largest Memories Yet Used

A new electronic, digital computer with one of the largest memories yet incorporated in any computing device has been built by the General Electric Company for use by the United States Air Force's Research and Development Command at its Flight Research Laboratory, Wright Air Development Center, Dayton, Ohio.

The computer, known as OARAC (Office of Air Research Automatic Computer) can deliver rapid-fire answers in typewritten form to mathematical puzzles which would take expert mathematicians years to solve. It can make as many as 100 calculations per second.

OARAC is a serial, decimal, single-address machine with magnetic-tape input and output, and magnetic-drum internal memory. It is decimal in operation, that is, it uses a code of four binary digits to express a decimal digit.

The decimal system has one distinct advantage over the binary system. The redundancy introduced by the use of only 10 of the 16 possible combinations of 4 binary digits to represent the 10 decimal digits, creates a 6/16 probability of automatic detection of single errors due to transient pulses, and also provides a good means of detection of errors due to equipment failure.

The single-address type of operation was adopted, taking out one number from the memory to operate on the number present in the accumulator, or recording the number from the accumulator into the memory. Decimal serial operation is used throughout the machine; this means that all storage and all operations are serial from a decimal point of view with four binary digits stored and handled in parallel for each decimal digit.

The computer has a 10,000-word memory. Numbers and instructions can be stored anywhere and operations can be performed upon instructions as well as on numbers. This simplifies programming whenever the need occurs for calling in new values of the variables or when using subsequences.

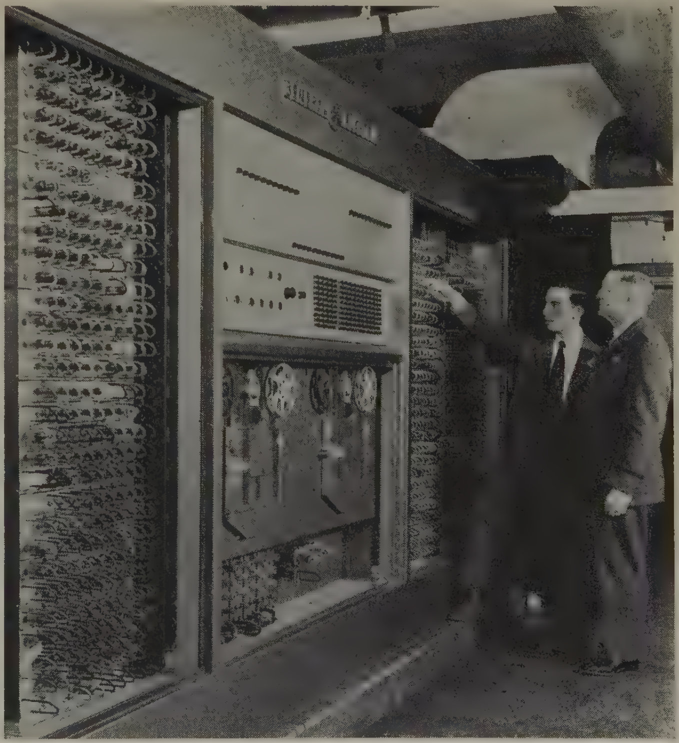
A single magnetic head per track is used both for recording and playing back. This makes positioning of the heads relatively simple and eliminates one of the main causes of delay in the successful installation and operation of a new computer.

There are 50 sets of 4 parallel tracks with 200 words on each set. A word consists of a 10-decimal digit number, plus sign, or of a 2-digit operation code and 5-digit address.

The same matrix is used to select the heads for recording and playback, the only difference being the level of gating.

The arithmetic unit contains a serial adder and three vacuum-tube storage registers. It can perform the following basic operations: add, shift, complement, count, and sense zero.

Brain of OARAC is this metallic drum which whirls at 3,500 rpm in operation. Surface speed on the outside of the drum is estimated at about 200 miles per hour. The maze of wires connect with magnetic record-playback heads which read information into or out of the unit



Air Force Brigadier-General L. I. David and General Electric engineer inspect OARAC. The center section of OARAC, containing operations panel and high-speed input and output tape mechanisms, is flanked on either side by rows of plug-in turrets which contain most of the 1,400 tubes and 7,000 diodes used

Using these five basic steps as building blocks, the computer can perform automatically any of its operations.

Positive numbers are carried throughout the machine as zero followed by the number itself; negative numbers by nine followed by the complement of 10^{10} of the original number, thus eliminating end-around carry.

The control unit consists of two address registers, one containing the address of the instruction being performed, the other containing the address of the number being recorded into or played back from the memory. It also contains the circuits performing the built-in operations.

The operations built into the machine and performed by the use of the five steps mentioned before are: addition, subtraction, multiplication, division, read to or from tape, read from or to memory, conditional transfer of control, and a number of orders allowing high-accuracy operation and checking.

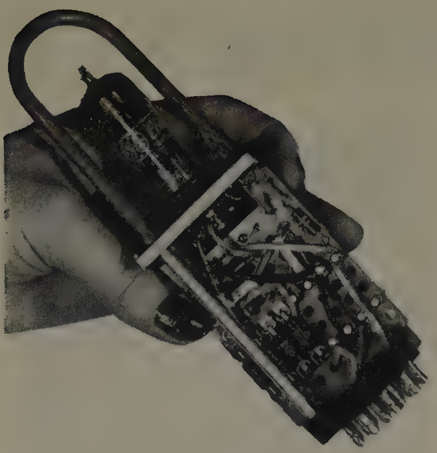
Serial addition time is 83 microseconds. Maximum access time, however, is 17 milliseconds and because this is a single-address machine, it cannot be programmed to perform faster then 8.5 milliseconds or 110 operations per second.

All control signals within the computer are either 50-volt 1/4-microsecond pulses, or a d-c switching voltage of zero or plus 40 volts.

Information is fed into and out of the computer on magnetic tape. A piece of information on tape consists of a word plus its address in the internal memory.

The tape preparation unit has a standard electric typewriter and automatically converts negative numbers into the complement of 9's code.

The printer allows complete flexibility in the determination of the printed page by



Approximately 1,000 turrets like the one shown represent keys to the thousands of numbers involved in the problems for solution by OARAC. Use of individual turrets is designed to reduce maintenance costs and problems, each turret being a complete circuit in itself. Seven different types of turrets are used, each representing a different type of operation

selecting switches located on the front panel:

1. The number of columns may be chosen from 1 to 10, the lines divided into groups of from 1 to 11 lines each or solid pages printed, the number of groups may be chosen between 5 and 15.
2. The numbers may be printed in blocks of digits with spaces between, the printing of numbers may be cut off at any position in the register, individually controlled for each column.
3. The decimal point may be omitted for the printing of differences and orders may be typed out by setting a special switch.

In the design of this computer, certain rules were adopted which followed logically from the foremost aims. Those aims were accurate and reliable operation, simple design with proved components, ease of operation, and especially ease of maintenance.

First, a minimum of so-called hardware was striven toward. No complicated operations were permanently built in. The machine has been kept to a minimum of operations, allowing a few exceptions where a few components actually would save the programmer a large amount of work. This computer has a 10,000-word internal memory, allowing storing of a large number of subsequences which will have to be programmed only once and can be stored permanently on magnetic tape. Whenever the need for a logarithm or a square root occurs, the programmer will place the numbers upon which he wanted to operate in specific memory spots and order the computer to perform the required subsequence.

This reduction of components is a first step towards greater ease of maintenance and reliability of operation.

A second step was that by a careful use of symbolic logic, the whole computer was built, except for the memory input and output, with seven basic circuits. Those seven basic circuits perform all the required logical functions of storage, gating, choice, mixing, and regenerating. Those circuits are built each on plug-in assemblies. Those circuits plug into standard panels.

A relatively large number of germanium diodes are used; they are plugged into clips on the textolite cards of plug-in turrets. The main purpose for the particular construction of these turrets is that they enable easy air-cooling of the components, mainly the germanium diodes.

The small number of different circuits allowed extensive development work on each unit, and simplifies maintenance by reducing necessary spare parts storage to a minimum.

A third step towards greater ease of maintenance is in the method of construction, which enables plugging in and out of every component without connecting or disconnecting a single lead. Whenever the computer indicates that something is wrong, an operator, using the front panel controls, can find the area of the trouble very rapidly. He may change the questionable plug-in units and put the computer back in operation. Then, whenever time permits, he can plug the units taken out into test sets and determine whether the units are in operating condition.

As mentioned before, equipment failures are rapidly detected by wrong combination sensing. Equipment failure rapidly will cause such a forbidden combination to occur, causing the machine to stop and an alarm to ring. By inspection of the front panel lights, the operator then can recognize the general location of the trouble.

Errors due to faulty programming, or to a single transient failure, can be detected by the feature of roll-back built into the machine. At any point the programmer can perform a check either by programming by two different methods and comparing results or by leading to some known result. If the check is satisfactory, the computer proceeds to the next operation; otherwise it returns to the preceding check point and performs all operations over again. This can happen two times at any check point, the third time the computer gives up and rings an alarm.

The main part of the computer, made up of most of the standard plug-in units, is housed in a single cabinet approximately 16 feet by $2^{1}/_{2}$ feet by 7 feet. The four doors open upon racks containing nothing but the plug-in units; the doors serving as a wall to allow air-cooling of the tubes. The center sections contain the input and output mechanism (one each, more can be added in separate housing) and all that is required to perform manual operation and any problem could be run from the front panel.

OARAC, like other comparable large-scale general-purpose digital computers, can solve almost any problem which a mathematician can program.

Because of its large internal memory, OARAC is able to solve special problems, like high-order matrix inversions where the amount of required available data is beyond the capacity of most present-day computers.

One of the problems presently coded for OARAC is the solution of 1,011 simultaneous equations. This computer is particularly well suited for a problem of this type because of its large internal memory used in conjunction with its fast tape storage.

The problem which is at present being solved on OARAC involves calculations from the magneto-ionic theory. It is desired to obtain the index of refraction, the absorption index, and the polarization for radio waves, being propagated at low frequency, in an ionized medium in the presence of an external magnetic field.

These calculations are to be made at various frequencies, various values of electron density, collision frequency, gyromagnetic frequency, and dip angle, giving approximately 10,000 values of the aforementioned parameters. This will take a little over 200 hours of computation time on OARAC. It would take over 20 years for an experienced operator using a fully automatic desk calculator to do the same job.

Other typical problems to be solved on OARAC are differential equations, complicated algebraic equations, simulation problems, tables of functions, and almost any complex problems in physics, engineering, ballistics, and logistics.

Electronic Device Reacts Intelligently to Numbers Spoken into Telephone

An electronic device that intelligently reacts to numbers spoken into any ordinary telephone, which some day may make it possible to put through a call automatically by speaking the desired telephone number into the mouthpiece instead of dialing it, has been developed by Bell Telephone Laboratories.

It was pointed out, however, that the time when this may become an every-day possibility is still far in the future. The new system now reacts correctly to numbers from zero through nine when adjusted to the voice of any one person, although it will not tolerate careless enunciations or accents.

Ultimately it is hoped to extend the vocabulary of the device to recognize a few words, such as "go" and "stop."

Known as "Audrey," a convenient contraction of the words, "automatic digit recognizer," the device utilizes much of the same apparatus employed at a telephone central office, particularly relays. It operates on the principle of memory and matching by first listening to a spoken word, then sorting out the speech characteristics and matching them with a memory cell containing standard reference sound-wave patterns of the several numbers or digits.

For instance, when "one" is spoken, its characteristic roundness of sound is balanced against such a standard preserved within the machine. If the number is spoken clearly, the machine recognizes it by electrical shape and a light flashes on. When "two" is spoken, the machines sees or hears a different sound-wave pattern, and so on.

The instrument is one of a number o

Audrey, which has a special circuit which automatically determines which of ten numbers has been spoken into an ordinary telephone and flashes an appropriate light, is tested at Bell Telephone Laboratories by K. H. Davis, one of the designers

voice-operated systems developed at the Bell Laboratories over a number of years. Some of them have been in use for years in transoceanic telephony. Others have proved useful in suppressing electrical echoes in very long telephone connections. Until now, however, such devices had not been able to distinguish the differences between spoken words.

Audrey contains intricate circuits and is about as large as the average television-radio-phonograph console.

Axle-Testing Machine Simulates Actual Driving Conditions in Laboratory

A unique axle-testing machine, capable of simulating in a laboratory actual driving conditions that a truck weighing 80,000 pounds and traveling at a speed of 60 miles an hour would experience, was installed recently in the Alden Indoor Proving Ground of the Timken-Detroit Axle Company in Detroit, Mich.

The testing equipment, engineered and built by the General Electric Company, duplicates torques, stresses, and speeds that the drive axle of a truck or bus would encounter under both normal and strenuous loads.

Incorporating huge dynamometers, the largest ever used for the purpose, and intricate electronic equipment to control their action, this machine can impose tests on axles never before possible indoors.

A 350-horsepower dynamometer simulates the truck engine driving the axle through transmission gears, and can deliver up to 450 horsepower over a drive-shaft speed range of from 400 to 3,000 rpm. Integral blowers are provided for cooling to allow motoring speeds down to creeping speeds. Two output dynamometers, rated 550 horsepower 650–3,000 rpm, are attached to gears located at the ends of the axle and, by means of measuring devices, record the torque output. The combined measurements of the three dynamometers test the efficiency of the axle. The gears, located at the ends of the axle, allow wide variations of speed and load.

View of new axle-testing machine showing test stand in foreground with one output dynamometer on left and the input dynamometer on the right

Amplidyne equipment provides field power for the three dynamometers and a 750-kw motor-generator set. Only one motor-generator set is required because of special loop circuits installed in the system.

General Electric also supplied the operator's control console for the system and a unique cycling control which contains two strip chart recorders for measuring speed and torque.

Truck and bus axles are tested by placing them on the test stand and subjecting them to highway conditions by means of a magnetic tape. This tape, when run through the automatic cycling equipment, causes the dynamometers to respond to the impulses on the tape and exert the indicated speeds and stresses on the axle. The tape recorder provides repetition of the operator's speed and torque signals used in an initial manual test. As each stress is imposed, recording instruments indicate continuously the speed, torque, or load as well as provide a permanent record. The same test can be repeated many times until the durability or life expectancy of the axle is established. The recording tape can be filed, and the test repeated exactly at any later date.

Safety measures, consistent with dynamometer practice, are provided which offer protection both to operating personnel and equipment. These include overload and overspeed devices and dead-front enclosed floor-mounted cubicles for all control.

So far, the axle-testing machine has been used for life tests, endurance runs, and shock loading tests. Other tests are being developed.

Advertising Council to Conduct "Engineers Wanted" Campaign

In the spring of 1952, the Engineering Manpower Commission of the Engineers Joint Council asked the Advertising Council, a nonprofit public service advertising organization supported by American business, to undertake an advertising campaign in behalf of the nation's engineering shortage.

The Council's program seeks to encourage qualified high school students to consider engineering as a career by pointing out to them and to their parents the opportunities that exist in engineering today and in the years to come.

Volunteer co-ordinator of the "Engineers Wanted" campaign is Chester H. Lang (AM '43), vice-president of public relations, General Electric Company. Advertising materials have been prepared by Kenyon and Eckhardt, Inc., serving as the volunteer agency, with George T. C. Fry, vice-president, acting as account executive and William S. Stockdage as assistant executive. The Advertising Council's own executive on the program is Grant Harper.

The Council has prepared an advertisement for use in business and trade papers, offering a free booklet entitled "How Your Company Can Promote Engineering as a Career." The Council has also issued an

Future Meetings of Other Societies

American Society for Testing Materials. Spring Meeting. March 2–6, 1953, Hotel Statler, Detroit, Mich.

American Society of Tool Engineers. 21st Annual Meeting. March 17–20, 1953, Hotel Statler, Detroit, Mich.

Electrochemical Society. Spring Meeting. April 12–16, 1953, Hotel Statler, New York, N. Y.

Greater New York Safety Council. Greater New York Safety Convention. March 24–27, 1953, Hotels Statler and New Yorker, New York, N. Y.

Institute of Radio Engineers. National Convention. March 23–26, 1953, Waldorf-Astoria Hotel and Grand Central Palace, New York, N. Y.

Institute of Radio Engineers—Polytechnic Institute of Brooklyn. Symposium on Nonlinear Circuit Analysis. April 23, 24, 1953, Engineering Societies Building, New York, N. Y.

Institution of Electrical Engineers. Symposium on Insulating Materials. March 16–18, 1953, Institution Building, London, England

Metal Powder Association. 9th Annual Meeting. April 20–22, 1953, Hotel Cleveland, Cleveland, Ohio

National Association of Corrosion Engineers. 9th Annual Meeting. March 16–20, 1953, Hotel Sherman, Chicago, Ill.

National Electrical Manufacturers Association. March 9–12, 1953, Edgewater Beach Hotel, Chicago, Ill.

Protective Relay Engineers. 6th Annual Conference. March 23–25, 1953, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Tex.

advertisement to house magazines offering a booklet entitled "Engineering as a Career." This booklet is aimed at high school students, parents, and teachers. Additionally, 1-minute spot announcements have been prepared for radio, and articles and editorials are available for use in local newspapers, house organs, and school papers.

Courses in Automatic Control Offered by University of Michigan

The University of Michigan, College of Engineering, has announced two intensive courses in Automatic Control. The first is scheduled for June 15 to 20, 1953, inclusive, and the second for June 22 to 25, 1953, inclusive. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The purpose of the course is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

The courses are built around the principles and application of measurement, communication, and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamentals to more advanced problems. There will be 4 hours of lecture each morning and 3 hours of demonstration in the afternoon. Extensive use will be made of computing, instrumentation, and servo laboratories on the campus. The role of analogue computing methods will be emphasized.

Further information may be obtained by writing to Professor M. H. Nichols, Room 1523 East Engineering Building, University of Michigan, Ann Arbor, Mich. April 15, 1953, is the closing date for registration.

Oak Ridge Announces Spring and Summer Courses

The first advanced course in industrial uses of radioisotopes, an advanced course in autoradiography, and three more basic radioisotope technique courses will constitute the spring and summer course offerings of the Special Training Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn.

In addition, the Division will give on April 30 and May 1, 1953, a symposium on "Management Problems in the Industrial Application of Radioisotopes." Management personnel of companies interested in incorporating radioisotopes or other atomic energy products into their research or production activities are invited to attend the symposium, which will be devoted to those special problems imposed on management by the use of these materials. Speakers who have coped with these problems successfully will be the symposium leaders. Subjects to be covered will include dealing with the Atomic Energy Commission (AEC) (contracts, information sources, available products, and other services available from AEC), legal problems encountered in radioisotope use, insurance problems, public relations, the role of consulting laboratories, safety and procurement of radioisotopes, and the equipping and staffing of radioisotope laboratories.

Dates for the course offerings are as follows: Industrial use of radioisotopes, April 20–May 1, 1953; autoradiography course, June 15–26, 1953.

Basic courses lasting for 4 weeks will begin on June 8, July 6, and August 10, 1953.

The industrial course will offer instruction in a number of techniques which have become important in research or production. These include wear studies, gauging procedures and devices, radiography, isotope marking process, industrial processes, chemical reaction studies, analytical chemistry applications, isotopes in the biological industries, textile and laundering problems, instrumental developments, and industrial autoradiography. Emphasis will be on techniques involved rather than actual results.

The autoradiography course is the second to be offered by the Special Training Division, another having been offered in the summer of 1951. Specialists in this field will conduct various phases of the course, which is intended for research-level personnel. George A. Boyd will be the course director.

The basic courses will be the 33d, 34th, and 35th to be offered since the series was initiated in 1948.

Additional information and information blanks may be obtained from the Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

MIT Competition for Fellowships in Industrial Management Opened

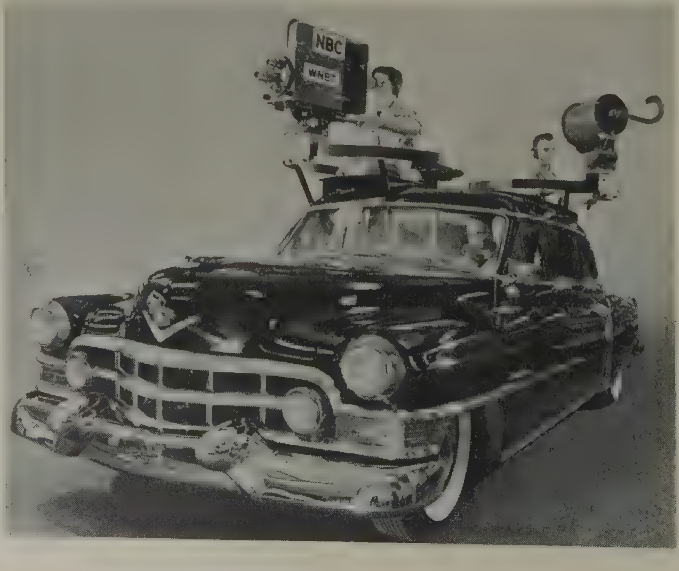
The School of Industrial Management at the Massachusetts Institute of Technology (MIT) has opened its competition for the fellowships which will be available for graduate students in the school in 1953–54.

Recent college graduates whose major studies have been in science, engineering, or engineering administration and who want advanced work in industrial management are invited to apply. Fellowships will include full tuition and may carry additional cash stipends of up to $2,100 for married men and $1,400 for single men.

The graduate program in the school, leading to the degree of master of science in Industrial Management, normally requires 2 years for those who have had no previous work in this field.

Fellowship recipients, selected by the

Sedan Designed for Televising Parades



Sedan engineered specially for televising inauguration parade accommodates four technicians and driver. Camera man works through a turret opening that is cut through top at front right corner while transmitters send beamed wave to receiver worked by man in turret opening at left rear of car. Picture is then relayed to fixed receiver and by coaxial cable to network

Graduate Committee of the School of Industrial Management, will be those applicants who appear to have the greatest potentialities for future leadership in business. This decision will be based upon such factors as outstanding scholastic performance, demonstrated initiative and leadership ability, evidence of high moral and ethical standards, favorable personality traits, and, within certain limits, successful working experience.

Most applicants presumably will be students graduating in June 1953 from colleges accredited in science or engineering, or recent graduates from such schools with 1 or 2 years' professional experience.

Applications should be filed by March 1, 1953, or as soon thereafter as possible. Further information and application blanks may be obtained from Professor Thomas M. Hill, School of Industrial Management, Massachusetts Institute of Technology, Cambridge 39, Mass.

World Power Conference Issues Statistical Yearbook

Statistical Yearbook, Number 6, issued by the World Power Conference, brings the annual statistics of fuel and power forward to 1950 and in many cases to 1951, and includes also some additional and revised data on fuel and power sources. Much of the information has not been published before.

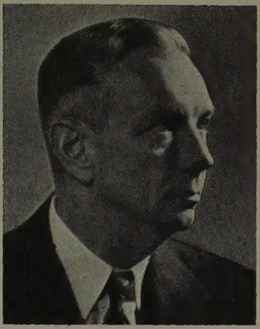
The aim of the World Power Conference, in publishing successive numbers of its *Statistical Yearbook*, is to provide closely defined statistics which are comparable as between different countries and over a period of years which goes back to 1933. The great majority of the statistics conform to these requirements and have been specially supplied by the National Committees of the World Power Conference and by official and semiofficial organizations in the countries concerned. The definitions to which they conform are reproduced in the text. Where such statistics have not been received, the gaps have been filled as far as possible with statistics, at least approximately comparable, reproduced by permission from publications of the United Nations; these figures are distinguished by being printed in italics.

It is believed that the Yearbook contains the most comprehensive collection of closely defined and comparable statistics of fuel and power yet published.

Engineers Joint Council now acts as Secretariat for the United States National Committee of the World Power Conference. The distribution of the yearbook in the United States is handled by The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y. Price is $5.25 per copy.

T. H. Chilton Named Chairman of Manpower Commission

Dr. Thomas H. Chilton, technical director, Engineering Department, E. I. du Pont de Nemours and Company, has been named chairman of the Engineering Manpower Commission.



T. H. Chilton

Formerly serving as president of the American Institute of Chemical Engineers in 1951 and then as vice-president of Engineers Joint Council in 1952, Dr. Chilton has been active in the profession since graduating from college.

Dr. Chilton was graduated as a chemical engineer from Columbia University in 1922 and joined Du Pont in 1925. He is the author of articles on ammonia oxidation, flow of fluids, heat transfer, distillation, and transfer.

He is a member of the American Chemical Society, The American Society of Mechanical Engineers, American Society for Engineering Education, American Association for the Advancement of Science, Tau Beta Pi, and Sigma Xi.

IRE Announces Sessions for 1953 National Convention

Forty-three technical sessions have been arranged for the Institute of Radio Engineers (IRE) National Convention to be held in New York, N. Y., March 23–26, 1953.

The first technical sessions on Monday afternoon, March 23, will be devoted to Antennas, Television, Circuits, Electronic Computers, Instrumentation, and Radio Location, Navigation, and Air-borne Electronics.

On Tuesday morning, March 24, sessions on Microwave Antennas, Television, Circuits, Electronic Computers, Instrumentation, and Significant Trends in Air-borne Equipment will be held.

Subjects of the afternoon session will be Antennas, Circuits, Electron Devices, Instrumentation, and Trends in Mobile Communications.

Wednesday morning, March 25, meetings will include sessions on Electron Devices, Circuits, Noise and Modulation, Television Broadcasting, Quality Control Methods Applied to Electron Tube and Electronic Equipment Design, and Acoustics for the Radio Engineer.

In the afternoon, sessions on Electron Devices, Information Theory, Communications Systems, Television Broadcasting and Ultrahigh Frequency, Microwaves, and Acoustics for the Radio Engineer will be held.

The final day of the convention, March 26, will include sessions on Nucleonics, Information Theory, Medical Electronics, Broadcast and Television Receivers, Microwaves and Radio Telemetry in the morning.

The afternoon sessions will be on Audio, Engineering Management, Information Theory, Broadcast and Television Receivers, Microwaves, and Remote Control Systems.

The opening meeting of the convention will be held on Monday morning, March 23.

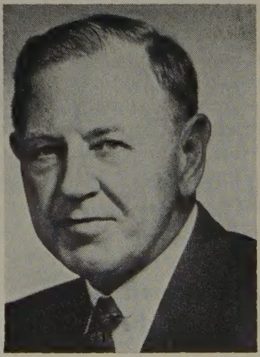
Nonlinear Circuit Analysis to Be Subject of Symposium

Nonlinear Circuit Analysis is the topic of an international symposium to be held on April 23 and 24, 1953, at the Engineering Societies Building Auditorium in New York, N. Y. This symposium, organized by the Polytechnic Institute of Brooklyn with the co-operation of the Institute of Radio Engineers (IRE) Professional Group on Circuit Theory and with the cosponsorship of the Office of Naval Research, Air Research and Development Command, and the Signal Corps, will be of particular interest to those working in the field of nonlinear systems. It is intended to cover the basic exposition of nonlinear phenomena and the fundamental mathematical methods of analysis as well as illustrative applications to nonlinear electronic circuits, magnetic circuits, feedback systems, and feedback control systems. American and European authorities, who have made original contributions to the art, will participate.

No registration fee will be charged for admission to the symposium. Proceedings of the Symposium on Nonlinear Circuit Analysis will be published by October 1953 at a cost of $4.00 per copy. Members of the IRE Professional Group on Circuit Theory may obtain copies at $3.00 per copy. Orders for the Proceedings, accompanied by check or money order made out to "Treasurer, Nonlinear Symposium," will be accepted in advance. Copies of the detailed program, hotel accommodation information, and registration forms are available on request. All correspondence should be addressed to: Polytechnic Institute of Brooklyn, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, N. Y.

Pigott Named President of Engineers Joint Council

Reginald James Seymour Pigott has been elected president of Engineers Joint Council and T. A. Marshall, Jr., has been appointed permanent secretary. Mr. Marshall also will continue to serve as executive secretary of the Engineering Manpower Commission.



R. J. S. Pigott

Mr. Pigott, former president of The American Society of Mechanical Engineers and presently a consultant to the Gulf Research and Development Company, was recently retired as chief engineer, Director of Engineering Division, Gulf Research and Development Company. Mr. Pigott is past president of the Society of Automotive Engineers, past president of the American Society of Measurement and Control, and past president of the Instrument Society of America.

He is the author of many technical articles and papers on power plant design, fluid flow, instruments, lubrication, supercharges, and others. Mr. Pigott is a member of Tau Beta Pi, Sigma Tau Sigma, and Sigma Xi.

Mr. Marshall is a graduate of Georgia Institute of Technology and was formerly with the Metropolitan Life Insurance Company. He is a member of The American Society of Mechanical Engineers and Tau Beta Pi.

Fellowships in Electronics Announced by MIT

A number of Graduate and Advanced Research Fellowships are offered by the Massachusetts Institute of Technology (MIT) for study and research in the field of electronics. They are known as Industrial Fellowships in Electronics and are sponsored jointly by a group of industrial organizations concerned with the advancement of electronics and its applications.

Applicants must satisfy the requirements for admission to the Graduate School on recommendation of the Department of Physics or the Department of Electrical Engineering. Recipients of such fellowships will pursue programs of study and research leading towards advanced academic degrees in physics or electrical engineering, specializing in electronics.

There will be awarded a few Advanced Research Fellowships to candidates possessing the doctor degree or its equivalent who without enrolling as graduate students wish to pursue advanced studies and research in the field of electronics at MIT.

Recipients of a Graduate Student Fellowship will be awarded a stipend varying between $1,500 and $2,400 according to their experience and qualifications, and in addition will be granted a credit to meet the tuition fee. Advanced Research Fellowships will range from $3,000 upwards according to the qualifications of the recipient. Applicants for an Industrial Fellowship in Electronics should communicate with the Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass. Application should be made at least 4 months prior to the intended date of entrance.

Applications Invited for Research Fellowships

A number of industrial research fellowships in physics, chemistry and chemical engineering, metallurgy, ceramics and minerals, engineering mechanics, and electrical engineering are being offered by Armour Research Foundation of Illinois Institute of Technology.

Research fellows will attend Illinois Institute of Technology half-time and work in the Research Foundation half-time in a graduate program leading to advanced academic degrees. They are employed full-time by the Foundation during the summer.

The Foundation awarded nine fellowships in 1952, and plans to award about 15 in 1953. Fellowships begin with the school semester in September 1953, and continue through the summer for approximately 21 months until the end of the second academic year in June 1955.

Awards are made on a competitive basis to United States citizens under 28 years of age holding a bachelor's degree from an accredited engineering or scientific school or a liberal arts college with a major in the sciences.

In addition to tuition, fellows are paid $165 a month during the first academic year, $325 a month with a 2-week paid vacation during the summer, and $190 a month during the second academic year. Successful candidates are encouraged to accept full-time employment during the summer preceding the Fellowship at a rate of $300 a month.

Application forms may be obtained from the Office of Admissions, Graduate School of Illinois Institute of Technology, Chicago, Ill. Applications received prior to March 15, 1953, will be given first consideration.

Betameter Used for Control in Paper and Pulp Industry

Few industries have been more alert to the possibilities of atomic radiation than the pulp and paper industry. The gamma and beta rays emitted by radioactive materials have been employed to check this industry's equipment; to inspect its products; and to control production. Isotopes are being employed in several ways to revolutionize pulp and paper production control.

Developed by Isotope Products Ltd., as a gauge for measuring basis weight of paper, the betameter (see picture, *EE, Jan '53, p 15*) is perhaps the most spectacular application of radioactivity to paper-making. Isotopes in one head of the instrument emit beta rays which are recorded by a detector device in another head of the gauge. Paper, or any material, passed between the heads of the machine absorb a portion of the beta rays. This absorption is measured precisely and continuously and translated by electronics to pen recorders and, in increasing installations, to the controls of paper making machines.

Using isotopes thallium 204 and strontium 90, the betameter is becoming standard equipment in many of Canada's mills. And operators are finding more uses for it all the time. For example, it has been found that less material is wasted when a betameter is used to control the production. At one mill, when the stock chest containing pulp begins to empty, a weaker waste pulp suspension is pumped in. With a betamatic controller regulating the stock gate, the value which controls flow from the stock chest, this process can be continued and repeated until all waste has been used. Yet the betamatic, installed at the wet end of the paper machine, keeps grade of paper constant and within close tolerance of the preset basis weight standard.

The betameter is a good trouble-shooter too. Installed at the wet end of the machine, it measures both pulp and water. The gauge will, in fact, measure basis weight of any kind of material, wet or dry, passed between its source and detector.

A paper machine depends on perfectly steady operation and any change can be seen instantly on the betameter chart. In one case, a mill found the betameter trace moving down steadily. A check showed that the close-coupled Jordan beaters were not operating properly. Indeed, they needed continuous adjustment to keep the paper up to the betameter's exacting specifications.

The betamatic is an automatic version of the betameter. The electronic equipment which records variations in basis weight on a pen recorder is, in the betamatic, also linked to the gate control or other controls on paper-making equipment. Thus the betamatic automatically corrects control settings to maintain the prescribed basis weight. The control is thus continuous and tolerances of about ±2 per cent are now common on machines where the betamatic is installed.

The betameter has solved one fundamental problem of the paper manufacturer, continuous automatic control of basis weight. Now Canada's paper manufacturers have pointed the way to a new instrument which will solve another basic problem, variations across the paper sheet rather than down the length of the roll.

Variations across the paper sheet, along its profile, cause poor draw on presses and can lead to wrinkles, corrugation, and other defects. These variations are a bane to printers and are particularly troublesome when smaller units, like labels or envelopes, must be cut from the paper stock. The solution to this problem is now being tackled by application of isotope equipment.

Formerly, mill operators were obliged to cut narrow strips of paper across the web and weigh each strip individually. Then from the weights they constructed a chart by hand. This operation which took a half hour or more can now be accomplished in a minute or so with the beta profiler, a gauge developed jointly by Isotope Products Limited and The Foxboro Instrument Company.

The profiler accepts a strip torn from across the web and feeds it, through rollers, between beta source and detector. A pen recorder immediately constructs the chart, thus faults in slice adjustment can be corrected without delay.

Like most new isotope equipment, the beta profiler is simple to operate, for while atomic radiation brings new concepts and new materials into industrial use, the operation of radioactive instruments is basically straightforward. In the beta profiler all that is seen is the recorder and two switches. One switch turns the instrument on and off; the other sets the machine into one of four ranges by an ingenious cam and iris mechanism. Once set, the recorder reads the basis weight of paper passed through the instrument. Source and detector are buried deep in the instrument and need no adjusting. The adjustable range of the instrument covers basis weight of papers from 50 pounds per ream to 250 pounds. For thinner papers the profiler will accept folded sheet bringing the total weight up to 50 pounds per ream, and average out local variations. The profiler's detector is the same robust ionization chamber developed for the betameter

Balanced and automatically temperature compensated by a second source and a second detector, it is perfectly steady in operation.

The profiler uses a specially concentrated source of isotope strontium 90. This isotope is a fission product, waste from the operation of atomic piles. It has a half-life of 25 years and so needs no replacement. The thallium isotope in some betameter models has a half-life of 3 $^1/_2$ years. This does require replacement but at the same time broadens the betameter's range to control production of such fine papers as 10-pound basis weight cigarette paper.

Papers may be coated with practically anything: ink, size, gum, or tar. Regardless of the coating, isotope equipment similar in principle to the betameter, can be used to measure the thickness of coatings, as well as of paper.

In the betameter, the beta rays are transmitted through the paper. But the rays can be reflected from one side as well and in this way record the thickness of coating. Actually this application, known as backscattering, is more important in handling denser materials such as tin-coated steelplate. For coated papers, the betameter itself can be used.

If the coating thickness is large compared to any possible variation in the paper itself, one betameter unit is sufficient. This was the case recently in a mill which coats asphalt pitch onto paper. A single betameter gave good results. Where the thickness of coating is closer to the paper thickness, two betameters can be coupled up with a mechanism that records the difference in basis weight before and after coating. Installation of this betameter adaptation is now planned in a number of mills.

One project on the development books of Isotope Products Limited, is a density gauge. This instrument will measure density of fluids and suspensions. This is expected to be primarily of interest to the metallurgical industries. But applications of this instrument in pulp and paper work are anticipated as well.

The gammagage is another isotope instrument which has been tailored to fit the paper industry's needs. This instrument uses isotopes iridium 192 and cobalt 60 which emit gamma rays and it was designed to measure and plot corrosion inside paper digesters.

One of the most notable uses of radioactive tracers in industrial processing and the only instance where tracers have been employed by the paper industry, is a Canadian accomplishment. This work was carried out by the Pulp and Paper Research Association of Canada and the research staff of the Ontario Paper Company.

Pulp fibers were "labelled" by use of isotope iodine 131 which emits both beta and gamma rays of fairly low energy and has a short half-life, 8 days. Prepared in the form of insoluble silver iodide, this isotope adhered to pulp fibers and the radioactively marked fibers were mixed into the main feed stock. The researchers used scanning counters, sample counters, and autoradiographic devices to study the distribution of labelled fibers in the finished paper sheet. Some interesting variations were found and a further experiment along these lines is slated for a West Coast paper mill shortly.

Unique Ventilation System Installed in Canadian Mine

The only one of its type in Canada, a towering 20-ton exhaust fan, shaped like a huge malted milk container, has been installed by The International Nickel Company of Canada, Limited, to ventilate the underground workings of the new caving project at its Creighton Mine in the Sudbury District of Ontario.

The giant vertical fan, driven by a 350-horsepower motor weighing 5 tons, ventilates the workings by a flow of fresh air at the rate of 300,000 cubic feet per minute. The fan draws the air down from the surface, directly through the caved or broken ore, circulates it through the underground workings, and carries it back to the surface through a main return shaft. It is at the top of this shaft that the fan is mounted.

The fan stands 42 feet above its concrete base, and the diameter at the inlet is 15 feet. The 124-inch impeller has 12 stainless steel blades which are adjustable in pitch through 25 degrees to accommodate the load as the mining operation moves farther from the main return air shaft.

In the caving method of mining at these properties in the Sudbury area, gigantic masses of undercut ore, far underground, are induced to cave and disintegrate through tension and torsion as well as of their own weight. This low-cost bulk mining method, plus metallurgical practices, make it practicable for International Nickel to recover and treat lower grade ore.

As the Creighton caving program took shape on the drafting boards, primary consideration was given to devising a ventilation system which would provide for the flow of a steady stream of fresh air through the slusher drifts, passageways through which ore is drawn off after it has come through funnel-shaped boxholes beneath the mass of broken ore.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Multiloop Feedback Control

To the Editor:

The stability of a multiloop feedback control system is usually determined by setting up the system determinants and finding the denominator of either the "output ratio" or "error ratio."[1] It has been the author's experience that the expression for the denominator of these ratios may be written by inspection when the multiloop system concerned has one point common to all loops. The manner in which the desired expression is written is as follows:

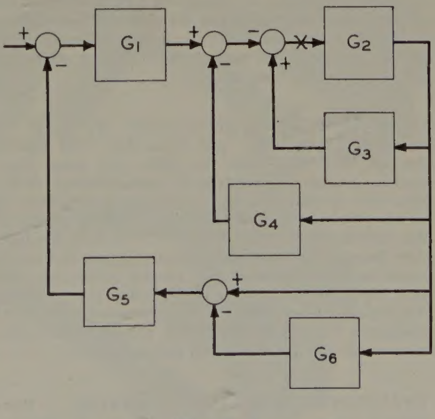


Figure 1

X is point common to all loops

$$1-(G_2G_3+G_2G_4+G_2G_5G_1-G_2G_6G_5G_1)$$

1. A block diagram of the system is drawn with the transfer functions of the several blocks designated by G_1, G_2, and so forth, as shown in Figure 1.
2. From the point common to all loops, every possible loop is traversed and the "transfer function" of each loop, with the appropriate sign, recorded.
3. The desired expression is equal to one minus the sum of these individual loop "transfer functions."

It is this expression that is the same as the denominator of the output or error ratio. To this denominator may be applied the standard stability criteria. Thus, Nyquist's[2] criteria requires that a polar plot of the expression exclude the origin for the system to be stable, or Routh's[3] criteria may be applied directly.

A typical multiloop system amenable to this conjectured procedure and the derived expression for this system are shown in Figure 1.

J. E. HART (AM '47)

(Naval Research Laboratory, Washington, D. C.)

REFERENCES

1. Automatic Feedback Control (book), **W. R. Ahrendt, J. F. Taplin.** McGraw-Hill Book Company, New York, N. Y., 1951.

2. Regeneration Theory, **H. Nyquist.** *Bell System Technical Journal* (New York, N. Y.), volume 11, number 1, January 1952.

3. Generalized Routh-Hurwitz Discriminant, **S. Sherman.** *Philosophical Magazine and Journal of Science*, volume 37, series number 7, number 271, August 1946.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCED MECHANICS OF MATERIALS. By Fred B. Seely and James O. Smith. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1952. 680 pages, diagrams, tables, charts, graphs, $9^{1}/_{4}$ by 6 inches, bound. $8.50. This textbook is intended for advanced undergraduate and first-year graduate students and continues the subject beyond the usual course in strength of materials. It aims to show the limitations of the ordinary formulas, to consider the conditions under which the limitations are significant, and to extend the subject to more complex topics. It also endeavors to give a more comprehensive view of the fundamental concepts and methods used in stress analysis. In addition to extensive revision throughout, two new parts have been added: influence of small inelastic strains on load-carrying capacity of members, and introduction to instability—buckling loads.

ASTM STANDARDS ON METALLIC ELECTRICAL CONDUCTORS. Sponsored by American Society for Testing Materials Committee *B-1* on Wires for Electrical Conductors. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1952. 254 pages, diagrams, tables, 9 by 6 inches, paper. $3.00. This publication contains the various American Society for Testing Materials standard and tentative specifications and methods of test pertaining to metals used as insulated and uninsulated electric conductors. Copper and copper alloys, copper-covered steel, aluminum, galvanized-steel core wire, and other galvanized iron and steel wire are among the metals and metal products included. General test methods are given for the determination of resistivity of electric conductor materials, tension testing of metallic materials, and Rockwell hardness and superficial hardness of metallic materials.

ASTM STANDARDS ON PAINT, VARNISH, LACQUER, AND RELATED PRODUCTS. Prepared by Committee *D-1* on Paint, Varnish, Lacquer, and Related Products. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1952. 784 pages, illustrations, tables, diagrams, charts, 9 by 6 inches, paper. $5.75. Over 200 standards are included in this compilation of specifications, test methods, and lists of definitions under the following categories: pigments; drying oils, paint, driers, and thinners; shellac, varnish, and varnish material; lacquer and lacquer materials; naval stores; and miscellaneous. Traffic paint service tests and paint weathering tests are covered. Twenty-three new standards have been added covering tests for properties of various solvents and coatings, specifications for calcium carbonate pigments and certain emulsions and measurements of both wet and dry film thickness.

ASTM STANDARDS ON TEXTILE MATERIALS. Prepared by American Society for Testing Materials Committee *D-13* on Textile Materials. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1952. 660 pages, illustrations, tables, diagrams, 9 by 6 inches, paper. $5.00. The following wide range of topics is covered by the 99 specifications, test methods, and tolerances presented: asbestos, bast and leaf fibers, cotton, glass textiles, rayon and silk, wool, pile fabrics, and felt; general fibers, fabrics, yarns, threads, and cordage; identification qualitative and quantitative analysis; resistance to insect pests and micro-organisms; testing machines. There are tests on snag resistance and stretch of hosiery and other specialized items. A group of useful tables is appended as well as certain proposed test methods, and an extensive glossary of textile terms is given including photographic illustrations of fabric defects.

CONTROL OF ELECTRIC MOTORS. By Paisley B. Harwood. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., third edition, 1952. 538 pages, tables, illustrations, diagrams, charts, $9^{1}/_{4}$ by 6 inches, bound. $7.50. In this book the characteristics of various types of motors are described briefly, and the ways in which these characteristics are used to control them are explained. The design, construction, and operating characteristics of a number of controllers and control devices are discussed, and methods of combining these devices to secure a desired effect are described. Owing to the rapid expansion of electronic control and the number of books on that particular aspect, the topic is omitted from the new edition.

DIRECT-CURRENT MACHINES FOR CONTROL SYSTEMS. By A. Tustin. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y., 1952. 306 pages, diagrams, charts, graphs, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $10.00. The potentialities of various types of d-c machines used in automatic controls are presented for the use of engineers and designers in industry and research. The common principles on which they all depend and the individual theory and characteristics of many types are discussed to serve as a guide to the selection and application of each machine.

THE ELECTRICAL FUNDAMENTALS OF COMMUNICATION. By Arthur Lemuel Albert. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., second edition, 1952. 531 pages, diagrams, charts, illustrations, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7.00. Intended as an elementary text for students of communication engineering, including telegraph, telephone, radio, and television, this book presents the principles upon which these forms are based. Explanations and illustrations used are taken from the communication industry itself. Each chapter contains a summary, a set of review questions, and illustrative problems. The book has been revised to conform with current developments.

ELECTRONIC ENGINEERING PRINCIPLES. By John D. Ryder. Prentice-Hall, Inc., 70 Fifth Avenue, New York, 1952. 505 pages, diagrams, charts, graphs, tables, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $9.00. With the object of supplying the physical fundamentals needed for an understanding of electron tubes, this volume covers theories of conduction, simple atomic structure, and generalized circuit analysis with linear and nonlinear circuit elements. A basic knowledge of a-c network theory and mathematics through simple differential equations is assumed. The physics involved in emission, space charge, and gaseous conduction phenomena is explained. Theory and applications are closely grouped, and applications are chosen mainly from the industrial field. A wholly new chapter on solid-state devices and the transistor has been added. Selected vacuum tube characteristic curves are appended.

HANDBOOK OF CHEMISTRY AND PHYSICS. 1952–1953. Charles D. Hodgman, editor-in-chief. Chemical Rubber Publishing Company, 2310 Superior Avenue, N.E., Cleveland, Ohio, 34th edition, 1952. 2,950 pages, tables, $8^{1}/_{2}$ by $5^{1}/_{4}$ inches, bound. $8.50. The new edition of this standard reference work contains over 300 pages of new or completely revised material as well as a considerable number of other changes and additions. Notable among the major revisions is the complete resetting of the tables on physical constants of inorganic compounds and physical constants of industrial organic compounds. Over-all, the volume provides an extensive compilation of specialized data in all branches of chemistry and physics and the closely allied sciences including a detailed index for ready reference. Information sources are quoted and literature references are cited in many instances.

HEAT TRANSFER PHENOMENA. By R. C. L. Bosworth. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 211 pages, illustrations, graphs, tables, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $6.50. Heat flow is described as a type of transport process in which physical characteristics are transferred through the movement of certain "carriers." It is in this light that the conduction of heat in gases, liquids, and solids, radiative transfer, forced and natural convection, and heat flow with simultaneous phase change are explained. An analogy of heat flow to other transport phenomena completes this monograph which should prove useful both to advanced students and technologists.

PRACTICAL ELECTRICAL WIRING. Residential, Farm, and Industrial. By H. P. Richter. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., fourth edition, 1952. 602 pages, tables, illustrations, diagrams, $8^{1}/_{4}$ by $5^{3}/_{4}$ inches, bound. $4.75 (textbook edition). Presents terminology, basic principles, and practical wiring instructions. All material in this new edition is based on the 1951 National Electrical Code. In addition to changes in the sections in which the Code was altered, the revision includes a greatly enlarged section on farm wiring and full coverage of stand-by generating plants for emergencies. The scope of the book is limited to the wiring of structures of limited size and at ordinary voltages, under 600 volts.

ESSENTIALS OF MICROWAVES. By Robert B. Muchmore. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y., 1952. 236 pages, charts, diagrams, illustrations, $9^{1}/_{4}$ by 6 inches, bound. $4.50. A brief but comprehensive review of the basic physical principles that underlie the operation of microwave devices. Concepts are expressed in common terms with mathematics reduced to a minimum. After giving the fundamental empirical laws of Maxwell, the application of these laws to waveguides, cavity resonators, antennas, and other electronic devices is described. A final chapter discusses microwave measurements.

PHOTOELECTRIC TUBES. By A. Sommer. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., second edition, 1951. 118 pages, diagrams, charts, $6^{3}/_{4}$ by $4^{1}/_{4}$ inches, bound. $1.90. This small monograph is devoted entirely to tubes of the emission type as distinct from the barrier-layer and photoconducting types. A brief survey of photoelectric emission is followed by a more detailed description of the manufacture and properties of photocathodes, an account of vacuum, gas-filled, and multiplier photocells, and discussion of their advantages, limitations, and applications. Additions in the new edition include information on the image converter and a survey of the fundamental features of television pickup tubes.

AUTOMATION. The Advent of the Automatic Factory. By John Diebold. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y., 1952. 181 pages, $8^{3}/_{4}$ by 6 inches, bound. $3. "Automation" denotes not only automatically controlled operation, but also such aspects as product and process redesign for automatic operation, the theory of communication and control, and the design of specialized machinery, the whole being viewed as a distinct area of industrial endeavor. This book is not intended to be a contribution to technological knowledge, but is primarily an essay on the business problems of automation and indicates how technological developments can be useful to the businessman. It points out the obstacles and limitations as well as the possibilities of automation; suggests solutions for problems which arise; describes existing examples of partial achievement; evaluates computers and their application to production scheduling, unit operations analysis, and similar control procedures; and discusses the important economic and social effects of the new technology.

DER EINFLUSS DER HARMONISCHEN AUF DEN ANLAUF DES SYNCHRONMOTORS. By Haroun Mahrous. Verlag Leemann, Zürich, Switzerland, 1952. 82 pages, charts, tables, diagrams, $5^{1}/_{2}$ by $6^{3}/_{4}$ inches, paper. Sw. Frs. 12.50. A study of the effect of harmonics on the starting of the synchronous motor. The general case of a synchronous salient-pole motor is investigated with reference to current and torque, including the influence of a variously unbalanced rotor. As a special parallel case, the turbosynchronous motor is discussed when the magnetic assymetry is damped out. Both the theoretical aspects and experimental investigation are covered. Presented as a doctor of philosophy thesis at the Eidgenössische Technische Hochschule, Zürich.

ELECTRICAL CODE DIAGRAMS. VOLUME II. By B. Z. Segall. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 18, N. Y., first edition, 1952. Various pagings, diagrams, illustrations, $11^{1}/_{4}$ by $8^{1}/_{2}$ inches, bound. $12.50. The second volume o this 2-volume set deals with equipment for general use with special occupancies, equipment, and conditions and with communication systems. Intended as a practical aid for doing work in accordance with the National Electrical Code, it shows diagrammaticall one or more illustrations for each code rule. Supplementary text is given where it is helpful. This background material demonstrates the reasons for the rules. Both practical and theoretical material are given. The first volume covered wiring design and protectio and wiring methods and materials.

ELECTROMAGNETICS. By John D. Kraus. McGraw-Hill Book Company, Inc., 330 West 42d Street New York 36, N. Y., first edition, 1953. 604 pages charts, diagrams, tables, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound $9. An extensive text on the basic principles of electromagnetic-field theory and their application to electronics, power, radiation, and propagation. The first half of the book serves as an introductory field-theor course and covers static electric and magnetic field steady currents, and changing electric and magneti fields. The second half, a continuation at a mor advanced level, treats plane waves in dielectric an conducting media, transmission lines, wave guide antennas, and boundary-value problems. A table units and various basic mathematical relations included in an appendix.